J Hales in exchange for the travels of Anachar

MEDICAL EXTRACTS.

ON THE
NATURE OF HEALTH,
AND
THE LAWS
OF THE
NERVOUS AND FIBROUS SYSTEMS.
WITH
PRACTICAL OBSERVATIONS:

BY
A FRIEND TO IMPROVEMENTS.

Robt. John Thornton

VOL. I.

THE THIRD EDITION.

There are three things which almoſt every perſon gives himſelf credit for underſtanding, whether he has taken any pains to make himſelf maſter of them or not. Theſe are, 1. *The art of mending a dull fire*: 2. *Politics*: and 3. PHYSIC.

From Dr. Beddoes's *Guide to Parental Affection.*

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LONDON:
Printed for J. Johnson, St. Paul's Church-yard; T. Cox, St. Thomas's-ſtreet, Borough; Dilly in the Poultry; Murray and Highley, Fleet-ſtreet; Richardson, Cornhill; Cuthell, Middle-Row, Holborn; White, Fleet-ſtreet; Becket, and Edwards, Pall-Mall; Hookham and Carpenter, Bond-ſtreet; H. D. Symonds, No. 20, Paternoſter-Row; Bell and Bradfute, Edinburgh; Archer, Dublin; Campbell, Philadelphia; and Allen, New-York.

1798.

THERE is a late publication, called MEDICAL EXTRACTS, a Work which would do credit to the *knowledge* of the firſt medical man in England, but to which the ingenious Author, with a ſingular ſhare of ſelf-diffidence, has not affixed his name.

From CRUIKSHANK *on the Nature of Perſpiration.*

THE taſk of an author is either to teach what is unknown, or to recommend *known truths* by his manner of adorning them; either to let new light upon the mind, and open new ſcenes to the proſpect, or vary the dreſs and ſituation of common objects, ſo as to give them freſh grace and more powerful attractions. To ſpread ſuch flowers over the regions through which the intellect has already made its progreſs, as may tempt it to return, and take a ſecond view of things haſtily paſſed over, or negligently regarded.

DR. JOHNSON.

TO

SIR JOSEPH BANKS, BART.

Preſident of the Royal Society, &c. &c.

SIR,

As a Patron of the Liberal Sciences, and more eſpecially, from the native benevolence of your diſpoſition, as the favourer of every attempt that may tend to alleviate the afflictions of mankind, this work is humbly offered to your notice.

It exhibits in a concentrated point of view the late improvements in Chemiſtry, and thoſe important diſcoveries reſpecting the animal œconomy, which theſe have ſuggeſted.

It places man in the center, and explains the relation he ſtands in with regard to the bodies which ſurround him.

The office of the lungs being known, and the alteration of the blood from the *Air* we breathe, and the influence of *oxygenated blood* on the nerves and animal œconomy, the ſtudy of phyſic is NOW become a pleaſing and intereſting purſuit. Nature appears ſublime and ſimple in her operations. The great myſtery of life is laid open to our view, and we are enabled clearly to comprehend, how this wonderful machine of ours depends every moment for its exiſtence on the due ſupply of *air* to our lungs, diſplaying at once the wiſdom and benevolence of THE ALMIGHTY. Having learnt this intimate connection, we ſee the grounds for the *pneumatic practice* lately inſtituted; and, from the exertions of phyſicians in this line, we are led to entertain ſome hopes of ſeeing even thoſe reſtored, who have already been deſpaired of by their friends. We are taught here, alſo, how to avoid many common and afflicting diſorders incident to the human frame; and, thanks to Dr. BEDDOES, and Dr. DARWIN, and the Rev. Mr. TOWNSEND, who ſtand confeſſedly the ſoremoſt among the modern improvers of medicine, the way to a prolongation of life and health, comparatively ſpeaking, is made eaſy:—and if the execution of this work has at all correſponded with the intention of the author, perſons of both ſexes, who have the power of fixing their minds for a few hours, and feel themſelves intereſted in the important enquiry, will ſoon be initiated into the new diſcoveries of chemiſtry, and the new theory and practice of phyſic, thereby introduced.

The labours of many enlightened phyſicians are here preſented in one body, and by notes, and ſome alterations in the text, and a methodical arrangement, it is hoped, they are rendered intelligible even to ſuch as have not been accuſtomed to ſtudies of this kind. As a juſt tribut of reſpect and eſteem,

I have the honour to ſubſcribe myſelf,

SIR,

Yours, &c. &c.

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3. *Aids* Digestion,
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Sometimes we have 4000 *Pounds leſs Weight of* AIR than *at other Times,* - - - - - - ib.

The Reaſon why the *Sinking* of the *Mercury* in the BAROMETER denotes *Rain,* - - - - - - - - - - - ib.

As a man 20 *Feet* under Water, ſupports more *Water* than another at the Depth of 10 *Feet,* ſo a Man at the Bottom of a *Valley* has more *Air* preſſing on him, than at the *Top* of a *high Mountain,* - - - - - - - 4

The BAROMETER alſo confirms this, - - - - - - ib.

The *Quickſilver* as we *aſcend,* having *leſs Air* to preſs on it, *ſinks* at the Rate of *a tenth Part of an Inch* every 90 *Feet,* - - - - - - - - - - - - - - - - ib.

Our *Frames* are *ſenſible* of THESE CHANGES, - ib.

They are *braced, vigorous,* and *ſtrong,* with a *large Body* of AIR upon them, - - - - ib.

Weak, languid, and *relaxed,* when the AIR is *light,* - - - - - - - - - - - - ib.

SECT. II. THE CHEMICAL PROPERTIES OF AIR.

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The *Diſcoveries* made on *this Subject* are the *moſt beautiful* of MODERN CHEMISTRY, - 5

They have *immortalized* the Names of PRIESTLEY, LAVOISIER, FOURCROY, and CAVENDISH, - - - - - - - - - - - ib.

The Honourable Mr. BOYLE conſidered our *Atmoſphere* as a *large chemical Veſſel,* in which an infinite Number of Operations were carried on, - - - - - - - - ib.

The AIR, therefore, in his Eſtimation, far from being a *ſimple elementary Body,* was *compoſed from all the Bodies of the Earth,* - ib.

MODERN CHEMISTRY has made *great Advances* in *this curious Reſearch,* - - - - 6

CHEMISTRY affords *two Methods,* that of
1. ANALYSIS, and
2. SYNTHESIS, - - - - - - ib.

The Method of ANALYSIS explained, - - ib.

The Method of SYNTHESIS explained, - - ib.

The *Derivation* of THESE TERMS, - - - - - - ib.

SECT. III. THE MODERN ANALYSIS OF ATMOSPHERIC AIR,

Or its *Separation* into its *two elaſtic Fluids*,
1. VITAL AIR,
2. AZOTIC AIR.

LAVOISIER'S 1ST EXPERIMENT.

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He put 83 *Grains* of crude MERCURY into a Veſſel which contained 100 *cubical Inches* of COMMON AIR, - - - - - - - - - 7

After five Days Application of a moderate Heat, there remained in the Veſſel only 86 *cubical Inches* of AIR, - - - - - - - ib.

14 *Cubical Inches* of AIR had therefore *diſappeared*, - - - - - - - - - - - - ib.

Now 14 *cubical Inches* of AIR weighs 7 *Grains*, - - - - - - - - - - - - - 8

The crude MERCURY was become a *Calx*, and inſtead of 83, it weighed *now* 90 *Grains*, - - - - - - - - - - - - ib.

The 7 *Grains acquired Weight* in the MERCURY in its *calcined State* muſt *therefore* have ariſen from the Abſorption of the 14 *cubical Inches* of AIR which had diſappeared, - - - - - - - - - - - - ib.

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LAVOISIER then examined the 86 *cubical Inches* of AIR remaining in the Glaſs after the *Calcination* was ended, and

1. It *deſtroyed an Animal* which was put into it, - - - - - - - - - - 8
2. It *extinguiſhed*, like Water, *the Flame* of a Candle, - - - - - - - - - ib.

Being found *adverſe* to *Life*, it was called AZOTIC GAS, from *α*, *privitive*; and *ξωη*, *life*, - - - - - - - - - - - - - - - ib.

Of its *other Appellations*, - - - - - - - ib.

1. *Phlogiſticated Air*,
2. *Non-reſpirable Air*,
3. *Noxious Air*,
4. *Mephitic Air*,
5. *Impure Air*.

LAVOISIER'S 2D EXPERIMENT.

He took the 90 *Grains* of the RED CALX of MERCURY, and put it into a Veſſel *void* of AIR, - - - - - - - - - - - - - 9

A *greater Heat* than in the laſt Experiment being applied, the MERCURY was *reduced back* to *its metallic State*, - - - - - ib.

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The Calx in this Proceſs loſt 7 *Grains* (only 83 *Grains* of running Quicksilver being procured), - - - - - - - - - - - 9

Now 14 *cubical Inches* of Air was found in the Veſſel, which weighed exactly 7 *Grains*, ib.

He then examined this Air, produced from the *Reduction* of the Calx, and
1. An *Animal* being placed in it, became remarkably *lively*.
2. A *lighted Body* being put into it, burnt with *uncommon Splendour*, - 10

This Air being found ſo *very favourable* to *Life* was called therefore Vital Air, - ib.

Of its *other Appellations*, - - - - - - - ib.
1. *Dephlogiſticated Air*.
2. *Pure Air*.
3. *Empyreal Air*.
4. *Highly reſpirable Air*.
5. *Oxygen Gas* (Acid making Air), from the Greek Words οξυς, *ſour*; and γεινομαι, to *beget*.

The *Reaſons* for this laſt Term Oxygen Gas, - - - 11
1. *Sulphur* combining with *Vital Air* forms an *Acid Air*, which being abſorbed by *Water*, is denominated Vitriolic Acid.

2. *Charcoal*,

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2. *Charcoal*, by Combuſtion, alſo combines with *Vital Air*, forming an *Acid Air*, which being abſorbed by *Water*, is denominated Seltzar, or the Aerial Acid Water.

3. The Oxyd or Calx of Arsenic is a perfect *acid Calx*.

Of the Diſcovery of the Vital, or Oxygen, Gas, - - - - - - - - - - - - - 11

Dr. Priestley, Mr. Scheele, and Lavoisier, each laid claim to *this great Diſcovery*, - - - - - - - - - - - - - ib.

Dr. Priestley is believed to have been the *Firſt* who diſcovered *this aerial Gas*, which is juſtly denominated the *Pride* of modern Philosophy, - - - - - 10

Lavoisier however is undoubtedly the *Firſt* who proved, by direct and exact Experiments, that the *Weight* which *Metals* gain by *Calcination* correſponds with *that* of the Air which they *abſorb*, - - - - - - - - - - ib.

And he was undoubtedly the *Firſt* who proved, that Atmospheric Air conſiſts of *two diſtinct aerial Fluids*, viz.

1. *Azotic Air*, and

2. *Vital Air*, - - - - - - - - - - - - ib.

SECT. IV. THE SYNTHESIS, OR COMBINATION, OF

1. AZOTIC AIR, and
2. VITAL AIR.

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Having repeated *theſe* 2 *Experiments* with the *ſame Reſult*, he took

1. The 84 *Cubical Inches* of Azotic Air, remaining after the *Calcination* of the 83 Grains of *Mercury*; and
2. The 14 *Cubical Inches* of Vital Air, given out by the *Reduction* of the 90 Grains of the *red Calx* of Mercury; and
3. *Combining them,* he produced 100 *cubical Inches* of Atmospheric Air, 12

Hence he concludes that Atmospheric Air is actually compoſed of *two heavy* and *ſolid Subſtances*,

1. Azot, and
2. Oxygen.

Which Bodies are rendered *aeriform* by their Combination with Caloric, or Matter of Heat, - - - - - - - - - - - - 14

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That Oxygen is a *ſolid Body* was proved by its forming part of a *metallic Calx,* - - - - - - - - - - 14

That Azot is a *ſolid Body* is proved (page 39) by its entering into the Compoſition of *Ammoniac* or *Alkali,* - ib.

That Caloric, or Matter of Heat, ſhould render Oxygen and Azot *gaſeous,* is not more extraordinary than that it renders Ice *fluid,* and heated to 212 it becomes *gaſeous* or *aeriform,* - - - - - - - - - - - ib.

Even a Diamond has been converted by Caloric into an *aeriform* Body, - - - - - - - - - - - - - ib.

Although theſe two Experiments of Lavoisier furniſh us with a very ſimple Means of obtaining *ſeparate* from each other the *two elaſtic Fluids* which compoſe our *Atmoſphere,* yet do they not give us an exact Idea of the Proportion in which *theſe two* enter *its Compoſition,* - - - - ib.

For the *Azotic Air* remaining after the *Calcination* of the Mercury ſtill retains a ſmall Part of the *Vital Air,* which the Mercury could not *ſeparate,*

1ſt. From the mutual adheſion of the *Oxygen* and *Azotic Airs,* and

2d. From the ſtrong Affinity which unites *Oxygen* with *Caloric,* - - - 15

In

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In conſequence of *theſe Affinities*, though the OXYGEN is torn from the *Caloric* and *Azot* by the ſuperior attraction of the *Mercury*, yet towards the Cloſe of the Proceſs there remains with the *Azotic Gas* ſome ſmall Portion of the VITAL AIR, - - - - - - 15

The true *Proportion* of
1. AZOTIC AIR, and
2. VITAL AIR,
is uſually,
In a Gallon of ATMOSPHERIC AIR, - { 3 *Quarts* of AZOTIC AIR, and
1 *Quart* of VITAL AIR, - ib.

A more *philoſophic*, though to the generality of Readers a leſs intelligible, Explanation of theſe Experiments, - - - - - - - 12

LAVOISIER'S 1ST. EXPERIMENT.

MERCURY at a certain Temperature, overcoming the Affinities of *Caloric* and *Azotic Air* for *Oxygen*, attracts and fixes within itſelf *that Principle*, - - - - - - - - ib.

An experimental Philoſopher might illuſtrate *this* by placing,
A NEEDLE in contact with *two Magnets* of different Powers,
which would repreſent,
the OXYGEN in union with the *Azotic Gas* and its own *Caloric*.

As a LOADSTONE would draw the Needle from the *two Magnets*; ſo the MERCURY draws to itſelf the Oxygen from the *Azot* and *Caloric*:

Hence 1. Its Converſion into a *Calx* or *Oxyd*.
2. Its *Increaſe* of *Weight*.
3. The *Azotic Gas* remaining when the Calcination is complete, - - - 13

The Term *Affinity* may be illuſtrated by a Bullet which is cut into two Parts;

If the Sides are brought into contact, they adhere by the Law natural to Bodies, called the *Attraction* of *Coheſion*, - 12

If a Grain of *Sand* interpoſe, or any roughneſs exiſt, the Particles being beyond the *Sphere of mutual Attraction*, they are no longer actuated by this law, - - - - - 13

The Attraction of Coheſion in Mercury at the *common Temperature*, hinders the Admiſſion of *Oxygen* for which it has an *elective Attraction*, - - - - - - - - - ib.

But when expoſed to a *ſtrong Heat*, the *Caloric* expands this Fluid; that is, inſinuates itſelf through the Body, and *ſeparates* its Particles, and, like the Pieces in the Bullet where *Sand* interpoſed, the divided Particles are no longer ſubject to the *Law of Coheſion*; then it is they obey the *Law of Attraction*, and each Atom of Mercury *attracts to itſelf* a Particle of *Oxygen*, juſt as a Loadſtone would draw to itſelf a Particle of Iron, - - ib.

The Loadstone only attracts *Iron*. This repreſents the Term *Affinity*. As the Loadstone does not attract *Tin*, ſo the Mercury did not attract the *Azot*, becauſe, as Chemiſts would ſay, it had *no Affinity* for it, - ib.

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The Temperature being increaſed,
The Affinity of CALORIC for *Oxygen*
is rendered ſuperior to
The Affinity of MERCURY for *Oxygen:*

Hence the *Oxygen is withdrawn* from the MERCURY, and hence,
1. Its *Decreaſe* in Weight.
2. Its *Reſtoration* from a Calx to a *Metallic Body,* and
3. The *Vital Air* (Oxygen and Caloric) obtained by this Proceſs, - - - 14

SECT. IV. THE ANALYSIS OF OXYGEN AIR,

Or its *Separation* into its *three Conſtituent Parts,*

1. OXYGEN,
2. HEAT, and
3. LIGHT.

Dr. INGENHOUSZ's *elegant Experiment,* - - 16

He took the *Steel-chain* of a Watch, and heated one Extremity *red hot;*

He then thruſt the *heated End* into a Phial containing OXYGEN AIR, - - - - - - ib.

It

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It *burnt away* like a Match, exhibiting the *brighteſt light*, - - - - - - - - - - 16

As it burnt, it caſt off brilliant Sparks, like a Firework, which fell to the Bottom in *Globules*, - - - - - - - - - - - - - ib.

Soon a *rapid diminution* of the OXYGEN AIR took place, - - - - - - - - - - - 17

If the OXYGEN AIR be *pure*, and the IRON *ſufficient*, the *whole* of the AIR will be *abſorbed* by the *Iron*, - - - - - - - - ib.

And if the Qnantity of the *Iron* be *inſufficient*, the *remaining* AIR *unabſorbed* will be found *perfectly pure*, - - - - - - - - ib.

That is, if 100 *Grains* of *Iron* be conſumed in 70 *cubic Inches* of OXYGEN AIR, the *whole Volume* of *Air* will *diſappear*, - - - - - - - - - - - - - - ib.

Now 70 *cubic Inches* of OXYGEN AIR weighs 35 *Grains*, and 100 *Grains* of *Iron* will, *when converted* into A CALX, weigh 135 *Grains*, - - - - - - - - - - - ib.

Since, where the *Iron* is *not ſufficient* to *abſorb* all the OXYGEN AIR employed, the *remaining* OXYGEN AIR is nevertheleſs found *pure*, the AZOTIC AIR left us, after the *Calcination* of the *Mercury* in the firſt Experiment, page 8, *could ariſe* from *no other Cauſe* than its *Separation* from the OXYGEN AIR.

This Experiment alſo ſhews that AZOTIC AIR *retards* the *Union* of OXYGEN with *Bodies attracting it*, and in ſome Caſes *altogether prevents it*, - - - - - - - - 16

How

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How much *ſlower* is the *Calcination* or *Ruſting* of IRON under *other Circumſtances!* - - - 16

The ROUND GLOBULES thrown off, as the *Iron* was *burning*, being collected, was found to be *martial Æthiops*, and *equalled* the *Weights* of IRON and of the OXYGEN AIR *employed* and *conſumed*, - - - - - - - ib.

A *more philoſophic Account* of THIS EXPERIMENT.

At a *certain Temperature* IRON has a *ſtronger Affinity* for the OXYGEN than CALORIC and LIGHT have, - - - - - - - - - 17

The IRON *therefore attracts to itſelf* the OXYGEN, with which it *combines*, - - - - ib.

And the CALORIC and LIGHT becoming *diſengaged* are rendered *active*, and *evident to* the *Senſes*, - - - - - - - - - - - - ib.

As the *Calcination* of MERCURY in LAVOISIER's Experiment laſted *ſeveral Days*, the *Diſengagement* of CALORIC and LIGHT was *extremely ſmall* for each particular Moment of Time, and *therefore* not *perceptible* to the Sight, - - - - - - - - - - - - - - - - 17

The HEAT alſo of the Furnace was confounded with it, which made it neceſſary to relate the above Experiment, where the *Combuſtion* of the METAL was *more rapid*, or, more juſtly ſpeaking, the *Decompoſition* of the OXYGEN AIR, - - - - - - - - - - - - - - - - ib.

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When we are ſailing on the Water in a ſtill Day, diſtant Objects appear to meet us, but *our Reaſon* corrects the Deluſion, - - - - - - - - - - - - - - - - ib.

When we behold the Sun, moving from Eaſt to Weſt, *Philoſophy* again aſſumes its Empire, and we are convinced it is ſtationary, - - - - - - - - - - - - - - ib.

If we take a Priſm, it diſplays to us a Variety of Colours; *our Reaſon* tells us here alſo, that theſe colours ariſe from the Rays of Light, and are not in the Priſm, - - - 18

So of the Combuſtion of Bodies, the CALORIC and LIGHT are not from *the Wax* of our *Candles*, but from the *Oxygen Air*, which, as we ſaw in the laſt Experiment, *becomes*, under certain Circumſtances, *decompoſed*, - - - - - - - - - - - - - - - - ib.

SECT. V. THE SYNTHESIS OF WATER,

Or *its Compoſition* from its *two Principles*,

1. HYDROGEN, and
2. OXYGEN.

WATER is neither that *compound* or *ſimple Element* formerly ſuppoſed, - - - - - - - 18

DR. PRIESTLEY'S CELEBRATED EXPERIMENT.

In the Middle of a Glaſs Tube he put ſome *calcined Lead*, - - - - - - - - - - - ib.

To

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To the two Ends, he affixed Bladders filled with *inflammable Air*, - - - - - - - 18

Having applied a ſtrong Heat to the Middle of the Tube, he preſſed the Bladders, - - ib.

The INFLAMMABLE AIR ſoon *diſappeared*, - 19

The RED LEAD re-aſſumed its *original metallic Splendour*, - - - - - - - - - - - - ib.

No OXYGEN GAS was *evolved*, - - - - - ib.

A *Queſtion* then aroſe, whence *this Property* in INFLAMMABLE AIR, which the *Anti-phlogiſtians* would aſcribe to the Evolution of OXYGEN GAS? - - - - - - - - - ib.

The INFLAMMABLE AIR which had appeared was ſaid to have been *abſorbed*, and was now called *Phlogiſton*, - - - - - - - - 19

But *this* muſt have occaſioned an *Increaſe* of *Weight*, if INFLAMMABLE AIR or PHLOGISTON be Matter, whereas on the contrary the *metallic Lead* weighed *lighter* than in its State of *Calx*, - - - - - - - - ib.

Fortunately for the *new Doctrines* of *Chemiſtry*, the Honourable Mr. CAVENDISH reſolved this Difficulty, - - - - - - - ib.

He

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He paſſed the *electric Shock* through Oxygen Air blended with Inflammable Air and formed WATER, - - - - - - - - 19

The Inflammable Air in Dr. Priestley's Experiment had united with the Oxygen Air evolved from the metallic Calx, and Water was produced, - - - - - - ib.

This was afterwards proved by the *French Chemiſts* to have been *the Fact*, - - - - ib.

85 *Grains* weight of Oxygen Air, and 15 *Grains* of Inflammable Air, produce exactly 100 *Grains* weight of Water, - - - - - - - - - - - - - ib.

The Properties of Inflammable Air, - - - - - 19

1. It *deſtroys Life.*

2. It is 15 Times *lighter* than *common Air.*

3. It *explodes* with *common Air,* provided any Body in actual Inflammation be preſent.

Dr. Priestley's Experiment.

Of the *Production* of Inflammable Air from *Iron* and *diluted vitriolic Acid,* - - - - - - - - - - ib.

This ariſes from the *Decompoſition* of the Water, and not from the Iron or vitriolic Acid, - - - - - - - ib.

SECT. VI. THE ANALYSIS OF WATER;

Or its *Separation* into its *two Principles*,

1. HYDROGEN, and
2. OXYGEN.

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MEUSNIER'S FAMOUS EXPERIMENT.

{He put ſome IRON WIRE into a Gun-barrel, 21

{He carefully noted down the Weight, - - ib.

{He ſo contrived it, that WATER glided down the Barrel, - - - - - - - - - - - - ib.

{At the other Extremity he had an Apparatus adapted to receive any aerial Product, - ib.

Having applied Heat to the Middle of the Tube, where the IRON WIRE was, as ſoon as this became red hot, as the WATER paſſed along it, - - - - - - - - - 22

1. HYDROGEN AIR, or Inflammable Air, entered into the Recipient adapted to the Gun-barrel for receiving any aerial Body, and - - ib.

2. The *Oxygen* of the WATER being united to the IRON WIRE converted it into a *Calx*, - - - - - ib.

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3. The Gun barrel weighed *heavier* than before,—which *Weight* being *added* to *the Weight* of INFLAMMABLE AIR obtained, anſwered *exactly* to the Weight of the WATER, which had *diſappeared*, - - - - - - - - 22

The HYDROGEN AIR here proceeded from the Combination of the *Hydrogen* of the WATER to the *Caloric* of the Furnace, - - - - - - - - - - - - - - ib.

INFLAMMABLE AIR the *French Chemiſts* call HYDROGEN GAS, from the Greek Words υδωρ, *water*; and γεινομαι *to produce*, - - - - - - - - - - - ib.

SECT. VII. THE ANALYSIS OF CARBONIC ACID AIR, OR FIXED AIR;

Or *its Separation* into its *two Conſtituent Parts*,

1. CHARCOAL, and

2. OXYGEN AIR.

MR. TENANT'S INGENIOUS EXPERIMENT.

He took a Glaſs Tube, into which he put ſome PHOSPHORUS and powdered MARBLE, - - - - - - - - - - - - - 23

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Now PHOSPHORUS is a *ſimple Body*; that is, one with whoſe Compoſition we are as yet unacquainted, - - 23

But MARBLE is compoſed of,
1. *Carbon* or Charcoal combined with
2. *Oxygen,* i. e. Carbonic Acid, and
3. *Calcareous Earth,* - - - - - - - - - - - 24

For if *diluted* VITRIOLIC ACID be poured on MARBLE, this Acid having a ſuperior Attraction for the *calcareous Earth* than the *carbonic Acid* has, it unites with the *calcareous Earth,* - - - - - - - - - - - - - ib.

And the *carbonic Acid* becoming diſengaged attracts to itſelf *Caloric,* and eſcapes in the Form of *Gas,* - - - - ib.

Hence MARBLE is ſaid to contain *Carbonic Acid Air,* or *Fixed Air,* - - - - - - - - - - - - - - ib.

Mr. TENANT having applied a quick Heat to the PHOSPHORUS and MARBLE in the Tube, the *Reſult* was
1. *Phoſphoric Acid* and *calcareous Earth.*
2. *Phoſphorus* and *calcareous Earth,* and
3. *Carbon* or Charcoal, - - - - - 23

Or, in other Words, at a certain Temperature PHOSPHORUS overcoming the Attraction of the *Carbon* for *Oxygen,* divorces it of *that Principle,* and becomes in conſequence,
1ſt. *Phoſphoric Acid,* which unites with the *calcareous Earth* of the MARBLE.

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The PHOSPHORUS having then no more *Oxygen* to convert it to an Acid, we have,

2dly. *Phoſphorus* combined with the *ſame Earth,* and

3dly. The *Carbon* or Charcoal left in its ſimple State, - - - - - - - - 24

We owe our firſt Knowledge of *Fixed Air* to Dr. BLACK, - ib.

But that *Water* abſorbed *this Air,* and was made SELTZER or PYRMONT WATER; and that if *Iron Filings* be put into this *acidulated Water,* it becomes a *Chalybeate,* the ſame nearly as the TUNBRIDGE WATER, we are indebted to the happy induſtry of Dr. PRIESTLEY, ib.

It is ſtill however a Queſtion, whether *Water* actually abſorbs *Fixed Air,* and *Marble* contains *the ſame,* or whether they poſſeſs only THE PRINCIPLES of THIS AERIFORM BODY, viz. *Carbon* and *Oxygen*? - - - - ib.

SECT. VIII. THE SYNTHESIS OF FIXED AIR;

Or *the Combination* of its *two Principles,*

1. CARBON or Charcoal, and
2. OYYGEN AIR.

The CHARCOAL obtained in the laſt Experiment was burnt in OXYGEN AIR, - - - 26

The

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The Carbonic Acid Air, or Fixed Air, *obtained, equalled* the *Weights* of the Charcoal and the Oxygen Air employed, - 26

Fixed Air is compoſed of 28 *Parts* of Charcoal to 72 of Oxygen Air, - - - - ib.

Or in other Words, 144 *cubic Inches* of that Air will ſaturate or take up 28 *Grains* of Charcoal, - - - - - - - - - - - ib.

The Properties of Fixed Air are,

1. It is ſpecifically *heavier* than common Air.

2. It is adverſe to both *Flame* and *Life,* - ib.

Sect. IX. The Analysis of Adeps, or Animal Fat;

Or its *Separation* into its *two Conſtituent Parts,*

1. HYDROGEN, and

2. CHARCOAL.

Of the *Diſtillation* of *animal* and *vegetable Subſtances,* - - - - - - - - - - - - 27

Vegetable Oil is proved to be compoſed of *Hydrogen* and *Carbon* or Charcoal, - - - 28

That

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The *ſpecific Gravity* of the Liquor is now conſiderably *diminiſhed,* and the other Principle, or HYDROGEN, is predominant, - 37

For from Diſtillation, *Alcohol,* or Spirit of Wine, is obtained, - - - - - - - - ib.

That *Alcohol* is chiefly *Hydrogen,* may be proved by its combining with *Oxygen,* and forming WATER, - - - - - - - - - 38

Thus 8 *Ounces* of *Alcohol* will produce by combuſtion 9 Ounces of WATER, - - - ib.

We have next the *acetous Fermentation,* - - ib.

This is no other than the abſorption or imbibing of *Oxygen* from the AIR, - - - ib.

The laſt Proceſs of the Fermentation is the *Putrefactive,* - - - - - - - - - - - ib.

In this the ſmall Reſidue of *Oxygen* and *Carbon* evaporates in the Form of CARBONIC ACID GAS, or Fixed Air, - - - - - - ib.

The *Hydrogen* eſcapes in the Form of HYDROGEN GAS, or Inflammable Air, - - ib.

And nothing remains but a ſmall Reſiduum of CARBON and VEGETABLE EARTH, - - ib.

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The Progreſs is different with Subſtances containing *Azot*, - - - - - - - - - 38

Thus *animal Bodies* putrify immediately; or if the Putrefaction be preceded by either of the other Stages, their Duration is too ſhort to be perceived, - - - - - - - - - ib.

Hence it is that *animal Excrements*, which contain a Quantity of *Azot*, are added to the Elements capable of Putrefaction, to form Compoſts on Dunghills, - - - ib.

The Addition of *Azot* not only accelerates the putrefactive Proceſs, but combining with the *Hydrogen*, a new Product is formed, viz. AMMONIAC, or Volatile Alkali, - - 39

That AMMONIAC is compoſed of *Azot* and *Hydrogen* we have the following Proof,

If AMMONIAC be applied to a *metallic Oxyd*,

1. The *Metal* is *revived*,
2. *Water* is formed,
3. *Azotic Gas* is obtained pure, - - - ib.

Here the *Oxygen* of the METALLIC OXYD unites with the *Hydrogen* of the AMMONIAC, and *Water* is formed, and the *Azot*, the other Principle of Ammoniac, is in conſequence diſengaged, - - - - - - - - ib.

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Of the *poiſonous Vapour* which iſſues from *putrefying Subſtances,* - - - - - - - - 40

The *late* PLAGUE in *Philadelphia,* which ſwept off 4000 Perſons in a few Months, originated from *this Source.* (This will be treated on at large under the Article *Fever.)*

The ABSURD CUSTOM of *burying* the *Dead* in *Churches.*

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He inveſts *Calcutta*, - - - - - - - - - ib.

The gallant Reſiſtance made by the Governor, Mr. HOLWELL, - - - - - - - - 47

He is obliged at length to ſurrender to the Soubah; after being promiſed, upon the Honour of a Soldier, "*That no Injury* "*ſhould be offered him or his Garriſon*," - ib.

He is conducted with 146 other Priſoners to a Place called the BLACK-HOLE Priſon, - ib.

The Symptoms that aroſe in conſequence of this confined Place, were

1. *A profuſe Sweat*,
2. *An inſatiable Thirſt*,
3. *Difficulty of breathing*, - - - - - ib.

They attempt to relieve themſelves by ſtripping off their Clothes, - - - - - - 48

Mr. HOLWELL promiſes the Serjeant of the Guard a thouſand Rupees, provided he could find Means to remove ſome of his People into another Place of Confinement, ib.

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The Offer was accepted: But *the Tyrant*, by whoſe Order alone ſuch a Step could be taken, *was aſleep, and no One durſt diſturb his Repoſe!* - - - - - - - - - - - - 48

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Mr. Holwell's peculiar Situation, - - - 50

The *extraordinary Reſpect* which was paid him, ib.

He is ſeized with ſtrong Palpitations of the Heart, and calls aloud for Water, - - - ib.

"*Give him Water,*" his People cried, nor would one of them attempt to touch it until *he* had drank! - - - - - - - - - - - - 51

Mr. Holwell finding himſelf ſtill more thirſty after drinking, he abſtained from Water, and moiſtened his Mouth from Time to Time by ſucking the Perspiration from his Shirt-ſleeves, which taſted *ſoft, pleaſant,* and *refreſhing,* - - - - ib.

Here the Oxygen of the Animal Oil might perhaps ſupply in ſome Degree the want of *that Principle*, which was held here in a leſs cloſe Bond of Union than in Water, ib.

They drop faſt now on all Sides, and a *pungent Steam* like Hartshorn (Hydrogen and Azot) aroſe from the Bodies of the Dead, ib.

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{That is nearly *one Child* out of *every Six*, - 57

{Theſe Children, many of them, foamed at their Mouths, and the Face looked *blue*, as though they were *choaked*, - - - - - - ib.

{This laſt Circumſtance led the Phyſicians to conclude that the Room in the Hoſpital was *too cloſe* and *crowded*, and hence that the Infants had not a *ſufficient Quantity* of GOOD AIR to breathe, - - - - - - - ib.

{The Contrivances that were deviſed to let in *freſh Air* and remove the *Bad*, - - - ib.

{The CONSEQUENCE was that out of 7650 Children born, there died *only* 279, - - 58

{That is not even *one Child* in *Twenty*, - - ib.

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{His Diſcovery of NITROUS AIR, - - - - ib.

{The MANNER *this Air* is produced, - - - ib.

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Its **Property** of *conſuming Vital Air*, - - 59

The Union of *Nitrous Air* with *Vital Air* forms **Nitrous Acid**, - - - - - - - - - - - - - - - - 60

Hence the *Decreaſe* of the *Bulk* of the *two mixed Airs*; as **Nitrous Acid** occupies but a *ſmall Space* in compariſon with theſe *two Airs*, - - - - - - - - - - ib.

This *Decreaſe* marks the **Quantity** of *Vital Air* in any given Portion of *Common Air*, - ib.

By **this Test**, Dr. **Priestley** perceived, that there was leſs *Vital Air* in his Study than on the Outſide of his Houſe, - - - - ib.

And that the Air in the Neighbourhood of *York* was not ſo good as the Air near *Leeds*, - - - - - - - - - - - - - ib.

That is, the Bulk of the Air in the firſt Trials was not *diminiſhed* equally by the **Nitrous Air**, as in the latter Trials, - - - - ib.

Lavoisier's *Eudiometer*, - - - - - - - 61

He places a cylindrical glaſs Tube inverted over Quickſilver, - - - - - - - - - ib.

He then paſſes into it ſome *Phoſphorus*, - - ib.

This being ſet on fire conſumes all the *Vital*, or *Oxygen*, Part of the Air, - - - - - ib.

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Phosphorus, like other combuſtible Bodies, attracts *Oxygen*, the Particles being once ſeparated by heat beyond their Sphere of mutual Attraction, or the Attraction of Coheſion, - - - - - - - - - - - - - - 61

The *Phoſphorus* becomes, in conſequence of this union with *Oxygen*, **Phosphoric Acid**, - - - - - - - - ib.

The **Phosphorus** obtains by this Converſion into an *Acid* an *Increaſe of Weight* exactly correſponding to the Weights of the *Phoſphorus* and the *Oxygen Air* conſumed, - - 62

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Lavoisier's Experiments to aſcertain the **Purity** of the **Air** *abroad*, in the *General Hoſpital*, and at the *Theatre*, - - - - ib.

Abroad there was 27 Parts **Oxygen Air** in an Hundred, - - - - - - - - - - ib.

In the *Hoſpital* there was 25 Parts **Oxygen Air** in an Hundred, and in the *upper Parts* of the *ſame Room* leſs, - - - - - - - ib.

And in the Pit of the *Theatre* only 21 Parts in an Hundred, - - - - - - - - - 63

Whence it is evident, that the Quantity of **Oxygen**, or **Vital**, **Air** had been *diminiſhed* in the *Theatre* in the Proportion of 27 to 21, or nearly *one Fourth*, - - - - ib.

That is, it was *one Fourth* leſs fit for Reſpiration than before, - - - - - - - - - ib.

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Of the *Circulation* of the Air, - - - - - - - - - 64

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The Air of a Room 30 Feet long, 25 broad, and 30 Feet high, containing 100 Spectators, would be rendered perfectly *mephitic* in four Hours and a Half, were it not for the *Circulation* of *the Air*, - - - - - 65

The *Effects* of *impure Air* on the *Mind* and *Body*, - - - - - - - - - - - - - 66

Dr. Thornton's *Propoſal* to *diffuſe* Vital Air in *Mines, Churches, crowded Rooms,* and *Hoſpitals*, - - - - - - - - - - 67

His *Obſervations*, and *Propoſal*, for rendering the *Bathing Rooms* at Bath more *ſalubrious*, ib.

Of the *Production* of Oxygen, or Vital, Air, and the Proſpect, as Chemiſtry advances, of obtaining this at a *very moderate Rate*, - 68

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An eaſy and cheap Proceſs for removing the *foul Air* of a Room, and throwing in *good Air*, - - - - - - ib.

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1ſt. *Oxygen*, or *Vital*, *Air*, and
2d. *Azotic Air*, - - - - - - - - - 69

Soon by Reſpiration we have,
3dly. *Fixed Air*, - - - - - - - - ib.

At length the *Oxygen Air* is wholly ABSORBED, and the *remaining Air* is compoſed of,
1. *Azotic Air*, and
2. *Fixed Air*.
Both which Airs are adverſe to Life, - - ib.

A *Queſtion* here naturally ariſes, WHAT HAS BECOME OF THE OXYGEN, OR VITAL, AIR, DEPRIVED OF WHICH AN ANIMAL DIES? - - - - - - - - - - - - ib.

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{A Note to ſhew that ſome Part of the OXYGEN, or VITAL, AIR is alſo expended in the *Formation* of FIXED AIR and VAPOUR, - - - - - - - - - - - - ib.

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{The Reaſon why *Lime-water* detects the preſence of FIXED AIR, - - - - - - - - - - - - - - ib.

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{The *Oppoſition* that this great Diſcovery at firſt met with, - - - - - - - - - - 73

{It was obſerved,

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2d. That the *Practice* of this great and good Man *declined* from the Moment he publiſhed to the World his ever memorable Diſcovery, - ib.

{The Conduct of the *ſenior Phyſicians* at BONONIA, - - - - - - - - - - - - - ib.

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Of the CIRCULATION,
1ſt. From the *right Cavities* of the *Heart* THROUGH THE LUNGS to the *left Cavity* of the *Heart,* - - ib.
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The Office of *Reſpiration* was unknown to the late Dr. HUNTER, - - - - - - - 77

A valuable *Quotation* from that learned Teacher, - - - - - - - - - - - ib.

IF EVER we ſhould be happy enough, ſays he, to diſcover clearly the Object of *Reſpiration,* we ſhall doubtleſs, as clearly ſee, that *this Organ* is as wiſely contrived for an *important Office,* as we now ſee the Purpoſe and Importance of the Heart, and vaſcular Syſtem; which, till the Circulation of the Blood was diſcovered, was wholly concealed from us, - - - - - ib.

The *Blood,* as it comes in contact with the AIR, expanding the Lungs, works many *chemical Alterations* in it, - - - - - - - 78

1ſt. The *Charcoal* of the Blood forms with the *Vital Air,* FIXED AIR, - - - ib.

This is proved by making an Expiration through a Tube containing *Lime-water,* which will become inſtantly TURBID, - - - - - - - - - - - - - - ib.

Or if *Venal Blood* be confined in a Phial containing *Vital Air,* the whole of *that Air* will be converted into FIXED AIR, - - - - - - - - - - - - - - - - ib.

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2d. The *Hydrogen* of the Blood forms with the *Vital Air* the HUMID VAPOUR, that iſſues from the Mouth, - - - 78

This you may prove by placing *venal Blood* in *Vital Air* in a warm Temperature, when preſently the Sides of the Veſſel will be covered with large Drops of WATER, - ib.

Or if black Blood be received in a Phial containing *Azotic Air*, AMMONIAC will be formed (which was proved Page 39 to be *Hydrogen* combined with *Azot*), - - - ib.

3d. The *Blood* alſo *abſorbs* within itſelf the *Vital Air*, which changes its *dark Colour* to a *brilliant Red*, - - - - ib.

Thus *changed*, it becomes

1. The SPUR TO ACTION of the *Heart* and *Arteries*,
2. The *Source* of ANIMAL HEAT,
3. The Cauſe of SENSIBILITY,
4. IRRITABILITY, and
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A *Quotation* from Dr. HARVEY, - - - - 79

Dr. GOODWIN's celebrated *Experiment*, which proves the Dependance of the CIRCULATION on RESPIRATION,—or rather on the Condenſation, or Fixation, of OXYGEN AIR in the Blood, - - - - - - - - - - - ib.

A valuable Quotation from Dr. SMITH, - - ib.

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SECT. VII. ON ANIMAL HEAT.

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Dr. CRAWFORD was the firſt who aſcertained by direct Experiments that *Animal Heat* was derived from the *Air*; but he knew not that *Vital Air* was *imbibed* by the *Blood* in the *Lungs*, - - - - - - - - - - 81

Dr. THORNTON next *improved* upon *this important Diſcovery*, - - - - - - - - - 83

This laſt Phyſician firſt publicly taught, at *Cambridge*, that the OXYGEN AIR imbibed by the *Blood* in the *Lungs* underwent a *Decompoſition* by THE OTHER PRINCIPLES in the animal Body, - - - - - - - - - ib.

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2d. A Supply of *Principles* attractive of *Oxygen*, diſengages *Caloric*, - - ib.

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He obſerved that when he had eaten *animal Food* or drank *fermented Liquors,* he conſumed the *Air* in the Diving-bell much *faſter* than when he lived upon *vegetable Food* and drank only *Water,* - - - - ib.

In my putrid fever, ſays the Rev. Mr. TOWNSEND, whenever I breathed *ſuperoxygenated Air,* as my Phyſician Dr. THORNTON often witneſſed,

1. My *Reſpiration* was *pleaſant,*
2. My *Oppreſſion* at my Cheſt *relieved,*
3. My *Appetite* was greatly *increaſed,* and
4. My *Digeſtion* was conſiderably *quickened,* - - - - - - - - - - - ib.

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The *Cauſe* of SNORING, - - - - - - - - ib.

Miners, when recovering from Aſphyxia ariſing from breathing *impure Air,* are conſtantly ſeized with *Nauſea,* and the *Stomach* rejects its *Contents* quite *crude,* - - ib.

JOHN

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JOHN HUNTER conveyed Worms, &c. down the Throats of Lizards, which were *torpid*, and always upon examination found the *Subſtances* which he had introduced *entire*, and without having undergone any the leaſt Alteration, - - - - - - - - - - - 91

But when the *Heat* was raiſed to 93 *Degrees*, the *digeſtive Proceſs* was eſtabliſhed, - - ib.

For the *Heat* rouſed up the *Actions* of the *Animal Œconomy*; the *Breathing* became *quickened*; and the *Blood*, having imbibed a greater quantity of OXYGEN AIR, containing *latent Fire*, to be *extricated* by *Principles* ſeparated by the Stomach, hence the *immediate Call* on the *digeſtive Powers* of *that Organ*, - - - - - - - - - ib.

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The *Fibres* of DIFFERENT ORGANS have APPROPRIATED STIMULI, viz.
1. OXYGEN AIR excites the *Heart,*
2. The GASTRIC JUICE the *Stomach,*
3. The BILE the *inteſtinal Canal,* and
4. LIGHT the *Pupil* of the *Eye,* - - - 110

A very ſtriking Experiment, which ſhews that VITAL AIR gives activity to the *Heart* and *Arteries,* - - - ib.

These *moving Fibres* are *affected* by *other* than *their natural Stimuli,* thus
1. *Ipecacuanha,* though injected into a Vein, affects the *Stomach,*

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2. *Jalap* the *Inteſtines*, and

3. *Mercury* the *ſalivary Glands*, - - 111

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The ELECTRIC FLASH which *theſe produced* when applied to the *Tongue* or *Ear*, - - 117

Wild and *ſavage Animals* have a *great Quantity* of *electric Matter*, as is ſhewn,
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2. By the *Erection* of *their Briſtles*,
3. By the *electric Flaſhes* that dart from their *Eye*, - - - - - - - - ib.

Inſtances of the ELECTRIC FLUID in *various Animals*,
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Monſ. VALLIS' *beautiful Compariſon* of the *electric Organs* of *this Fiſh* with the *Muſcles* of *our Body*, - - - - - - - - - 114

Of VITAL, or OXYGEN, AIR, as *related* to *Motion*, and the *nervous Electricity*, - - - 125

An *elegant Experiment* made by Dr. MAYOW, a Philoſopher of the laſt Century, - - - 126

SECT. XIII. ON TONE.

This Doctrine is ſupported by Dr. CULLEN,

1. By obſerving that Muſcles have *antagoniſt Muſcles*, and if one of theſe be cut, the other which is oppoſed to it will be in continued Action or Spaſm, - - - - - - - - - - 127
2. By the *Effects* of topical *Bleeding*, - 128
3. By the *Operation* of *aſtringent* or *tonic Remedies*, - - - - - - - - - 130

Tone, or *Strength*, is believed by the *pneumatic Phyſicians* to depend more upon the VITAL AIR in the *Blood* than upon TENSION, - - - - - - - - - - - - - 133

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It may be received as an Axiom, ſays the learned Author of the Guide to Health, "*That the living Power or Energy of an Organ is in proportion to the Quantity of* OXYGENATED BLOOD *that circulates through it,*" - - - - - - - - - - - - - - 138

Some Facts are adduced in *ſupport* of *this Doctrine,* - - - - - - - - - - - - ib.

APOLOGY.

Nos qui ſequimur *probabilia,* nec ultra id quod veri ſimile occurrerit progredi poſſumus, et refellere ſine pertinacia, et refelli ſine iracundia parati ſumus.

CICERO.

THE reader will ſoon perceive that the Author of MEDICAL EXTRACTS intended at firſt only to have preſented to the Public a conciſe view of "THE RELATION WE STAND IN WITH REGARD TO THE AIR WE BREATHE;" and as the *pneumatic chemiſtry* had been ſucceſsfully introduced into the practice of phyſic, this Volume would have been ſucceeded with "PATHOLOGICAL EXTRACTS RELATIVE TO THE EXHIBITION OF DIFFERENT AIRS:" but the progreſs of *this new ſcience* has been ſo ſlow, from the oppoſition which naturally awaits every great undertaking, that though the infant ſcion ſoon bloſſomed, and bore fruit, yet was the product ſcanty, and the tedious interval was therefore filled up at the deſire of ſeveral ſcientific friends, in giving "THE RELATION WE STAND IN WITH REGARD TO HEAT,—LIGHT,—CLOTHING,—FOOD,—EXERCISE,—and laſtly, THE OBJECTS WHICH EXCITE THE MIND THROUGH THE MEDIUM OF THE SENSES."

Firſt, it is explained "HOW THESE STIMULI IN A PROPER PROPORTION CONDUCE TO HEALTH." This occupies the two firſt volumes: and at the commencement of the third it is ſhewn "HOW THESE STIMULI TEND TO DESTROY HEALTH WHEN IN EXCESS."—and in this volume it is alſo ſhewn "HOW THE ANIMAL FRAME IS AFFECTED, WHEN THESE STIMULI ARE IN AN UNDER PROPORTION."—The fourth volume relates chiefly to the *nervous ſyſtem*, "BEING THE HISTORY AND EFFECTS OF THE EMOTIONS AND PASSIONS OF THE MIND AND THE LAWS TO WHICH THESE ARE SUBSERVIENT."

Thus, amidſt numerous avocations, I have attempted to explain, more extenſively than has hitherto been done, part of the SYSTEM, which was firſt eſtabliſhed by Dr. JOHN BROWN, and upon which the *pneumatic practice* is engrafted; a ſyſtem not in *itſelf* at any time *complete*, but to be conſidered as a FOUNDATION and a SCAFFOLDING, which will enable *future induſtry* to erect a SOLID and a BEAUTIFUL EDIFICE, eminent both for its *ſimplicity* and *utility*, as well as for the *permanency* of its *materials*—which may not moulder, like the ſtructures already erected, into the ſand of which they were compoſed: but which may ſtand unimpaired, like the NEWTONIAN PHILOSOPHY, a rock amid the waſte of ages!

> Deſine quapropter *novitate* exterritus *ipſa*
> expuere ex animo *rationem:* ſed magis acri
> judicio perpende, et, ſi tibi vera videtur
> dede manus.———
>
> LUCRET.

THE

PROGRESS

OF

CHEMISTRY.

We will not tire the reader with tracing the progreſs of chemiſtry from the earlieſt antiquity: but commence at that time when alchemiſts gave up their golden dreams, and turned their attention to improve by this art the ſcience of medicine.

The doctrines of Galen, which were ſpread over Europe, had taken ſuch firm root in the 16th century, that they ſeemed to defy all oppoſition. The remedies invented by chemical operations were at that time only adminiſtered by men in the loweſt condition of life, men without ſcience, without induſtry, and without honour. At length, however, Paracelsus appeared. He does not ſeem to have ſtudied phyſic in any of the eſtabliſhed ſchools; but while he travelled in different countries he picked up remedies from all ſorts of people, and particularly from the chemiſts of *Paracelſus.*

thoſe days. From theſe he learned the uſe of mercury and antimony, and from ſome hardy empirics the uſe of opium. When returning home from his travels he determined upon following his father's profeſſion, which was that of phyſic, and by theſe remedies he was able to cure many diſeaſes that baffled the inert remedies of the Galeniſts; and being of a bold and boaſtful diſpoſition, he made the moſt of theſe cures; while, at the ſame time, the partiality of mankind to novelty ſoon contributed to give him fame. He was ſo far more fortunate than other chemical practitioners, that he obtained the profeſſor's chair at the univerſity of Baſil. In this new ſituation he attempted a ſyſtem of phyſic, blended with the moſt extravagant and viſionary doctrines, ſupported and covered by a great deal of new and unmeaning jargon of his own. His lectures were chiefly employed in recommending his own chemical remedies, and declaiming in the moſt outrageous manner againſt the regular practitioners. He went even ſo far as publicly to burn the works of the Greek phyſicians; and he inſolently told the phyſicians of Baſil, that the very down of his bald pate had more knowledge than all their writers, the buckles of his ſhoes more learning than Galen or Avicenna, and his beard more ſenſe than all the univerſities together.

It ſeldom happens, that a man of but common abilities, and in the moſt retired ſcenes of life, obſerves ſuch a ſtrict uniformity of conduct, as not to afford prejudice and partiality ſufficient materials for drawing his character in different colours; but ſuch a great and irregular genius as PARACELSUS could not fail of becoming alike the ſubject of extremes of panegyric and ſatire. He has accordingly been eſteemed by ſome a ſecond Æſculapius; and others have thought that he was poſſeſſed of more impudence than merit, and that his being ſpoken of was more owing to the brutal ſingularity of his conduct, than to the cures he performed.

But in whatever eſtimation the merit of PARACELSUS as a chemiſt or phyſician be held, certain it is that he formed a ſect of practitioners, who appeared in oppoſition to the eſtabliſhed ſchools, which were then entirely followers of Galen, and theſe two adverſe parties agitated Europe for more than five hundred years. Nothing but ſucceſs could ſhake off the torpor or vanquiſh the bigotry of the Galeniſt.

Theſe at laſt finding their throne totter, called in the aid of the ſecular power, and employed it to cruſh their adverſaries. In France antimony was prohibited: but in Germany the chemiſts prevailed, and the Galeniſts were obliged ſometimes to have recourſe to the remedies of the chemiſts, when SENNERTUS, one of the moſt eminent of the Galeniſts in Germany, endeavoured to reconcile the two oppoſing parties.

Sennertus.

Sir Theodore Mayerne.

Very early in the ſeventeenth century, Sir THEODORE MAYERNE, who as a chemical phyſician had been much oppoſed and oppreſſed by the Galeniſts of France, was called over into England, where he was appointed firſt phyſician to the king, and continued to hold that office for more than thirty years after. His theory and his preſcriptions were like thoſe of the Galeniſts; but he was at the ſame time a great favourer of chemical medicines, and particularly of antimony; the medicine, with regard to which the two ſects were moſt eſpecially divided. It does not however appear, that he met with any violent oppoſition from the phyſicians in England: but, on the contrary, we find him becoming a member of, and acquiring great authority in, the London college. It is probable that his great credit put an end in England to all diſtinction between the Galenic and chemical practitioners; and, as in the year 1666, the faculty of Paris reſcinded their arret forbidding the uſe of antimony, the odious diſtinction between the Galeniſts and chemiſts gradually diminiſhed.

Van Helmont.

VAN HELMONT was the diſciple of PARACELSUS. He firſt gave the name of *gas* to thoſe vapours, which reſemble the air we breathe. He obſerved, that ſome bodies reſolve themſelves almoſt entirely into this aeriform ſubſtance. Not, adds he, that they are contained in this ſhape in thoſe bodies from which they are ſeparated; but exiſt in them in a concrete form, as if fixed or coagulated. He aſſerts, that 62 pounds of charcoal contain 61 pounds of gas, and only one pound of earth. The gas which flies off from calcareous earths and metallic bodies while they effervеſce in acids, did not eſcape his notice: the quantity contained in tartar is ſo great, that it breaks and burſts into ſhivers the veſſels in which it is diſtilled, if a free egreſs be not given to it. He applied this theory to the explanation of ſome phænomena of the animal œconomy. It is to this effluvium that Van Helmont attributes the fatal effects of the Grotto Del Cani; — the ſuffocation of workmen in mines;— the accidents occaſioned by the vapour of charcoal;— and that deleterious atmoſphere which is breathed in cellars, where ſpirituous liquors are in fermentation. He accounts for ſeveral diſeaſes upon this principle, and aſcribes the propagation of epidemical diſorders to noxious vapours with which the air is ſometimes infected. We are aſtoniſhed, ſays Lavoisier, in reading his treatiſe *de Flatibus*, to find an infinite number of facts, which we are accuſtomed to conſider as *more modern*, and we cannot forbear to acknowledge, that Van Helmont has related, at that period, almoſt every thing, which we are now better acquainted with, on this ſubject.

His ſkill was ſo great, and the phænomena his chemiſtry preſented ſo marvellous, that he was accounted a magician, and thrown into the inquiſition: and having with difficulty extricated himſelf from this abominable charge, he was releaſed, and retired to Holland, where he died in the year 1644.

I ſhall not preſume to decide which of the two great branches of natural philoſophy contributes moſt to the uſe and the ornament of life; but I think it natural that the mechanical department, where palpable maſſes of matter are brought into action, and motion is viſible in its progreſs, ſhould ſooner advance towards perfection than the chemical, where effects are produced by the inſenſible movements of imperceptible particles. It ſeems therefore to have its foundation in the order of things, that the philoſophers of the preceding age ſhould have been employed chiefly by aſtronomiſts and mechanics, and thoſe of the preſent by chemiſtry. Yet if the rule be at all juſt, what a violent exception,—ſuffer me to repeat it, have we in the inſtance of JOHN BAPTIST VAN HELMONT, who ſilently, and unperceived, diſcovered, if not the whole ſum and ſubſtance, yet certainly many of thoſe ſplendid facts which adorn the writings of PRIESTLEY, CAVENDISH, SCHEELE, LAVOISIER, and other philoſophers of the preſent day.

Bacon.

Not long after, the illuſtrious BACON formed plans for promoting the ſciences in general, and particularly the ſtudy of nature. In his comprehenſive view of things, he felt that chemiſtry might turn out one of the moſt curious and uſeful branches of national philoſophy. He adviſed the collecting of facts, and to compare theſe very maturely and cautiouſly, in order to diſcover, if poſſible, the cauſes and circumſtances upon which they depend, and declares that in this way only could any ſatisfactory ſyſtem be produced. Theories, he thought, were only uſeful ſo far as they aroſe from experiments already made, or as they might lead to new ones: for reaſoning may be conſidered as the eye of the philoſopher; but experience is his feeling; and this latter ſenſe ought conſtantly to rectify the too frequent errors of the former. If experiments, undirected by theory, are only a blind feeling; theory, without experiments, is a deceitful and uncertain viſion.—It was thus that this ſagacious philoſopher directed men in the true path of ſcience, and baniſhed that dark and abſtruſe philoſophy, which was built upon the abſurdeſt conjectures.

Boyle. On the day in which this great promoter of the ſciences died, BOYLE was born. He was in opulent circumſtances, and by the agreeableneſs of his manners, and goodneſs of his heart, he was peculiarly turned to the ſtudy of nature, which pleaſed him moſt, and the knowledge of which he cultivated in the way recommended by Lord BACON. He was poſſeſſed of that penetration and ingenuity of mind, which in experimental philoſophy ſerves to point out the ſhorteſt, ſimpleſt, and moſt uſeful, experiments, and which enabled him to deduce the moſt important truths from the moſt ſimple and inſignificant facts. Theſe are the talents we diſtinguiſh in an eminent degree in this philoſopher, and for which Sir ISAAC NEWTON was afterwards ſo remarkable. He examined the prevailing philoſophy of the chemiſts, and expoſes its weakneſs; but he does it with a temper, candour, and modeſty, which is truly admirable. What VAN HELMONT called *gas*, BOYLE denominated *artificial air*. Furniſhed with the new inſtruments with which he has enriched natural philoſophy, he repeated all VAN HELMONT's experiments in vacuo, in condenſed air, and in the open air. It is eaſy to ſee that nearly all the diſcoveries of this kind, which are uſually attributed to BOYLE, really belong to VAN HELMONT, and that the latter even carried his ideas much further. But one obſervation, which is particularly BOYLE's, does not ſeem to have been even ſuſpected by VAN HELMONT, viz. that there are bodies ſuch as ſulphur, camphor, &c. which *diminiſh* the volume of air in which they burn.

As I am about to draw the firſt line of the next ſketch, my hand is ſuſpended by the intruſion of a wiſh, that has often before mixed with my thoughts. It may, perhaps, be not a very inviting taſk, but methinks in the ſuperfluity of literary men, one at leaſt might be ſpared from other ſervices, to explore the dark volumes of ancient chemiſtry. Should any one, however, be able, ſo far to ſubdue his diſguſt, as to define, by careful enquiry, what degree of knowledge had been acquired from ſyntheſis and analyſis concerning the conſtitution of bodies, before the middle of the laſt century, I am ready to believe, that he would find more credit due to MAYOW than I dare venture at preſent to aſcribe to him. "*He* "*was acquainted with the compoſition of the atmoſphere,* "*—and perceived the action of oxygen, or vital, air in* "*almoſt all the wide extent of its influence. He was* "*well aware of the cauſe of the increaſe of weight in* "*metallic calces; and diſtinctly aſſerted, that certain* "*baſes are rendered acid by the acceſſion of the vital* "*air,*

Mayow.

" *air, or what has been ſince called oxygen, or the aci-*
" *difying principle. The doctrine of reſpiration is all*
" *his own. He has carried on his inveſtigation of this*
" *function from the diminution of the air by the breath-*
" *ing of animals to the change it produces in the blood*
" *during its paſſage through the lungs. The office of the*
" *lungs*," ſays he, " *is to ſeparate from the air and*
" *convey to the blood one of its conſtituent parts.*" He alſo adds, " *that on expiration ſomething noxious is*
" *thrown out* *." At the age of twenty-ſix he formed the peculiar ſyſtem which pervades all his works: his mind indeed diſcovers perpetual reſtleſſneſs, and an habitual tendency to advance; for having conveyed the *vital particles* of the air into the blood, here was now a very inviting reſting place;—but he could not be content without proceeding to inveſtigate what part they *afterwards* perform in the animal œconomy; a queſtion which ſtill occupies the patient induſtry of philoſophers of the preſent age. He ſuppoſes " *theſe particles are neceſſary to form the vital*
" *heat, and to ſupport muſcular action.*" The tranſlator of his works into Dutch (an honour which they did not obtain from any other people), in the

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* Vide Dr. BEDDOES's analyſis of Dr. MAYOW's works.

preface to them, affirms, *that his philoſophy found very little approbation in his own age**. So much does the fortune, both of truth itſelf, and of thoſe who ſpeak it, depend upon the diſpoſition of the times in which it is ſpoken. None indeed ſmiled upon the fair features of this new-born offspring of ſcience His name, therefore, as it never was echoed by popular applauſe, was ſoon forgotten among men, and his memory obliterated. In the *Biographia Britannica* there is no article appropriated to him. But henceforth, I hope, he will ſhare the glory of BACON and of NEWTON, and be named with due reſpect by all; and that when the enthuſiaſm of an Engliſhman ſalutes his country, as

> Magna parens frugum !———
> Magna virum !

MAYOW will be ranked amongſt the foremoſt in her liſt of *illuſtrious men*.

The united experiments of VAN HELMONT, of BOYLE, and of MAYOW, had made it evident that a great quantity of elaſtic fluid analogous to air was ſeparated from bodies in many operations;—that alſo in ſome other operations a portion of atmoſpheric air was abſorbed; but no one had any idea of the *exact quantities* either produced or abſorbed.

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* How much this doctrine was received by the learned of that time, conſult Vol. III. page 610, Note *.

Dr. Hales.

Dr. HALES was the firſt perſon who accompliſhed this uſeful purpoſe. Hence it did not eſcape this benevolent and indefatigable philoſopher, that the quantity of air *abſorbed* either by the burning of ſulphur or of candles, or by the reſpiration of animals, preſented different appearances, according to the quantity of air employed. He diſcovered that this abſorption of air is limited, and that it never proceeded beyond a certain point.

Dr. HALES, in the courſe of his experiments, has obſerved alſo the alternate *production* and *abſorption* of air, of which he, however, does not ſeem to have underſtood the true cauſe: the burning of charcoal, and other ſubſtances, furniſhed him with a great increaſe of air, but that air diminiſhed daily. This phænomenon depended upon the water which the Doctor uſed in theſe experiments: and it will be ſhewn hereafter, that moſt of theſe vapours, and particularly thoſe which we are accuſtomed to denominate *fixed air*, have a great affinity for water, which is capable of abſorbing more than its own bulk of *this air*.

The great number of experiments made by Doctor HALES, which may be found in chap. vi. of his *Vegetable Statics*, comprehends vegetable, animal, and mineral ſubſtances. He has examined into the effects of fermentation, chemical diſſolutions and combinations, the combuſtion of bodies, and reſpiration. Too much cannot be ſaid to induce the reader to peruſe his ineſtimable work. He will find in it a moſt inexhauſtible fund of meditation.

It is in this work, that we perceive the firſt traces of the exiſtence of air in thoſe waters, which are called *acidulous*. Dr. HALES has not only remarked that theſe waters contain four or five times more air than common water, but he alſo ſuſpected that they owed their remarkable ſparkling and briſkneſs to this air.

All the philoſophers of his time believed, that fire became fixed, and combined itſelf with metals, and that to this addition they owed their reduction to a ſtate of calx. Dr. HALES has not only diſcarded this error, but he has moreover advanced that air contributed to produce that effect, and that to it alone muſt be attributed the augmentation in the weight of metallic calces. He grounded his opinion chiefly in having obtained from 1922 grains of lead, only ſeven cubic inches of air;—whereas an equal quantity of minium afforded him 34 cubic inches.

Dr. HALES, in ſumming up his knowledge on this ſubject, compares the air to a true Proteus, now fixed, now volatile, entering into the compoſition of bodies, where it exiſts in a ſolid form, deprived of elaſticity, and of thoſe properties which formerly diſtinguiſhed it, adding gravity to theſe bodies, and under certain circumſtances alone capable of recovering its elaſticity, and becoming again an elaſtic and thin fluid, and therefore deſerving to be adopted among chemical principles, and to poſſeſs a rank which has hitherto been denied it.

Boerhaave.

The immortal BOERHAAVE, the honour of his country, of his profeſſion, and of his age, next improved upon the experiments of Dr. HALES, by not permitting the factitious airs to have any communication with *water*. It muſt be acknowledged, ſays he, that by chemiſtry we ſeparate from bodies an *elaſtic vapour*, and conſequently that this aerial matter reſides in them, but in ſuch a manner as not to have the properties of air, as long as it is combined and united;—but that whenever it is detached, it reſumes its former nature, and becomes *true air*, diſpoſed to reunite with other ſubſtances again, and remain quiet, but without loſing its real nature; for whenever it is freed from the bonds which retain it, it ſhews itſelf to be the ſame body. Nothing can be more certain than this *reſolution* and *compoſition*; and I would have given many examples of it, had I not lately read Dr. Hales' celebrated treatiſe on Vegetable Statics; in the ſixth chapter of which book, the author has collected with ſo much labour and juſtneſs, and has related in the beſt poſſible order, the experiments which have been made on this ſubject, ſo that he has exhauſted the ſubject. To theſe I refer my readers, and they will ſee how ART has arrived at the power of *unveiling* NATURE.

Hitherto chemiſtry, though it was much advanced, had been treated in a deſultory manner. A great number of facts were diſcovered; but none had attempted to generalize them, and form a ſyſtem; and though many particulars were known, yet the ſcience itſelf was not in exiſtence.

The illuſtrious **Becher** firſt began to collate, examine, and compare, the immenſe ſtore of chemical facts, and obſerve their relations. This man, whoſe genius equalled his knowledge, ſaw with a ſingle glance, the immenſe multitude of chemical phænomena. He invented a theory that ſoon obtained credit all over Europe. He was invited to Vienna, where he contributed to the eſtabliſhment of ſeveral manufactures, a chamber of commerce, and an India company; but the jealouſy of the miniſtry finally accompliſhed both his diſgrace and his ruin. He was not leſs unfortunate at Mentz, Munich, and Wurtzburg; which determined him to go to Haerlem, where he invented a machine for working a great quantity of ſilk in a little time and with few hands; but new diſgraces and misfortunes made him retire to England, and he died in London in 1682, at the age of 57, of a broken heart. *Becher.*

The theory invented by **Becher** was adopted and commented upon by **Stahl**, principal phyſician to the king of Pruſſia. Born, as **Becher** was, with a ſtrong paſſion for chemiſtry, which ſhewed itſelf in *Stahl.*

its early youth, he inherited a genius equal to that of Becher. His imagination was as lively, as brilliant, and as active, as that of his predeceſſor, and he had the advantage of being heard with attention. In the opinion of theſe two philoſophers *fire* enters into the compoſition of all inflammable bodies, and into metals and moſt minerals, and in that condenſed, compacted, fixed ſtate, it was called PHLOGISTON * (latent fire), to diſtinguiſh it from its condition when in a free ſtate.

The Doctrine of Phlogiſton.

We behold flame, we ſee bodies conſumed, we feel a pleaſing, and ſometimes a painful ſenſation, when we approach within the ſphere of theſe phænomena. Now is this fire as much a material body, as a piece of wood, or glaſs, or ſtone, or any other ſubſtance? If it be, whence does it ariſe? and what becomes of it?—We neither ſaw or felt it before the body was kindled; and when the fuel is conſumed, it no longer appears. In anſwer to theſe queſtions Becher and Stahl tell us,—that *fire*, or PHLOGISTON, is actually a material body, and liable to be modified by the influence of circumſtances. In bodies liable to burn, it exiſts in a latent ſtate:—place them in circumſtances in which combuſtion is produced—you then will behold it, perceive it operate, and feel its influence.—In bodies, as metals, though you do not perceive the flame, yet will you diſcover this principle by the alteration of their properties. Hence it is [*],

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* A word derived from the Greek word φλωξ, γος, flame, or fire.

If you take a piece of SULPHUR, and ſet it on fire, it will burn entirely away, without leaving any aſhes, or yielding any ſoot. During the burning of the ſulphur, a copious vapour, powerfully affecting the organs of ſight and ſmell, and the action of the lungs, is diſperſed. Means have been invented for collecting this vapour, and it is found to be a very ſtrong acid. The acid thus procured from the burning of the ſulphur, is incapable of being either burnt by itſelf, or of contributing towards the ſupport of fire in other bodies; the ſulphur from which it was procured was capable of both: there is a remarkable difference then, between the acid procured from the ſulphur, and the ſulphur itſelf. The acid is not the only conſtituent part of the ſulphur:—is it not evident then that it muſt have contained *ſomething* elſe, by which it was rendered capable of combuſtion. This *ſomething* is, from its remarkable property of rendering a body combuſtible, denominated therefore PHLOGISTON, or the *inflammable principle.*

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[*] The following examples are taken from DR. WATSON's *Chemical Eſſays*.

If you burn CHARCOAL in the open air, and hold a glaſs over its flame, you will perceive that it burns without emitting either any watery vapour or ſooty impurity; and nothing will remain, from a large portion of charcoal, but a ſmall quantity of white aſhes, which are incapable of any further combuſtion. The principle effecting the combuſtion of the charcoal, and diſperſed by the act of combuſtion, is the PHLOGISTON.

If you ſet SPIRITS OF WINE on fire, they will, if pure, burn entirely away; they differ from charcoal in this, that they emit a vapour: but they leave no reſiduum. You may, by proper veſſels, collect the vapour of burning ſpirits, and you will find it to be an inſipid water, incapable of combuſtion. The principle effecting the combuſtion of the ſpirits of wine, and diſperſed by the act of combuſtion, is the PHLOGISTON.

Some METALLIC SUBSTANCES burn, when ſufficiently heated, with a flame more bright than that of ſpirits of wine or charcoal; others burn or ſmother away like rotten wood; and moſt of them, when they have been kept in the open air in a proper degree of heat, loſe their metallic appearance, and are converted into earth. Thus red lead or minium is the earth procured from the burning of lead; and putty, ſuch as the poliſhers of glaſs and marble uſe, is the earth procured from tin. The principle effecting the combuſtion of metallic ſubſtances, and diſperſed in the act of combuſtion, is PHLOGISTON.

The *acid* of *ſulphur*;—the *aſhes* of *charcoal*;—the *water* of the *ſpirit* of *wine*;—the *earths* of *metallic ſubſtances*, are utterly incapable of combuſtion: their reſpective differences from SULPHUR, CHARCOAL, SPIRITS OF WINE, and METALLIC SUBSTANCES, with reſpect not only to *inflammability*, but to *ſmell*, *colour*, and *other properties*, are attributed to the PHLOGISTON which is diſperſed during the combuſtion of each of them.

From the ANALYSIS or decompoſition of SULPHUR, we conclude that the conſtituent parts of ſulphur are two—an *acid* which may be collected; and an INFLAMMABLE PRINCIPLE which is diſperſed. The reader will wiſh to ſee this ANALYSIS confirmed by ſyntheſis, that is, in common language, he will wiſh to ſee ſulphur actually made by combining its *acid* with the *inflammable principle*.

As this *inflammable principle* cannot be obtained in a palpable form ſeparate from all other bodies, the only method by which we can attempt to unite it with the acid of ſulphur, muſt be by preſenting to that acid ſome ſubſtance in which it is contained.—Charcoal is ſuch a ſubſtance, and by diſtilling powdered charcoal and the acid of ſulphur together, we can produce undoubted ſulphur. This ſulphur is formed from the union of the acid with the PHLOGISTON; and the charcoal may be by this means ſo entirely robbed of its PHLOGISTON, that it be reduced to the ſtate it is found after complete combuſtion in the open air.

Spirits of wine, we have ſaid, conſiſts of PHLOGISTON united with *water:*—and if we diſtil ſpirits of wine and the acid of ſulphur mixed together we ſhall obtain a pure yellow ſulphur, in no way to be diſtinguiſhed from common ſulphur.

But one of the ſhorteſt and moſt obvious ways of illuſtrating both the compoſition of ſulphur and PHLOGISTON of metallic ſubſtances is the following.—Upon melted lead pour the acid of ſulphur; collect the vapour which will ariſe, by holding a very large glaſs or other veſſel over the melted lead, and you will, as ſoon as the vapour is condenſed, obſerve ſeveral filaments of ſulphur ſticking to the ſides of the glaſs. Here, when the lead is in a ſtate of ſtrong fuſion, its PHLOGISTON is in a ſtate of diſperſion; and the acid of ſulphur inſtantaneouſly unites itſelf with this *phlogiſton*, and forms ſulphur.

I will in this place, by way of further illuſtration of the doctrine of PHLOGISTON, add a word or two concerning the neceſſity of its union with a metallic earth, in order to conſtitute a metal.

Lead, it has been obſerved, when melted in a ſtrong fire, burns away like rotten wood; all its properties as a metal are deſtroyed, and it is reduced to aſhes.—If you expoſe the aſhes of lead to a ſtrong fire, they will melt; but the melted ſubſtance will not be a metal, it will be a yellow or orange-coloured glaſs.—If you pound this glaſs, and mix it with charcoal duſt, or if you mix the aſhes of the lead with charcoal duſt, and expoſe either mixture to a melting heat, you will obtain, not a glaſs, but a *metal*, in weight, colour, conſiſtency, and every other property, the ſame as lead.

This operation, by which a metallic earth is reſtored to its metallic form, is called reduction. The aſhes of lead melted without charcoal is *glaſs*;—the aſhes of lead melted with charcoal becomes a *metal*; the charcoal muſt then have communicated SOMETHING to the aſhes of lead, by which they are changed from a glaſs to a metal.

Charcoal conſiſts of two things, of aſhes, and of PHLOGISTON; the aſhes of charcoal, though united with the aſhes of lead, would only produce *glaſs*; it muſt therefore be the other conſtituent part of charcoal, or PHLOGISTON, which is communicated to the aſhes of lead, and by an union with which the aſhes are reſtored to their metallic form.

The aſhes of lead we ſee then can never be reduced to their metallic form, without their being united with ſome matter containing PHLOGISTON; and they may be reduced to their metallic form, by being united with *any* ſubſtance containing

PHLOGISTON in a proper ſtate, whether that ſubſtance be derived from the animal, vegetable, or mineral kingdom (for tallow, or iron filings, may be ſubſtituted with ſucceſs in the room of charcoal, in the experiment of reducing the lead); and thence we conclude, not only that PHLOGISTON is a neceſſary part of a metal, but that it has *an identity* belonging to it, from *whatever ſubſtance* it be extracted.

The doctrines of pneumatic chemiſtry.

It had long been obſerved, that certain ſubſtances, ſuch as *marble*, *chalk*, and *limeſtone*, effervesced with acids;—that theſe ſubſtances were inſoluble in water; they were ſoft to the touch and inoffenſive:—But when treated with fire they aſſumed directly contrary properties, not effervescing with acids;—being eaſily diſſolved by water ſo as to form a tranſparent liquor;—and laſtly, they were rendered ſo cauſtic as to corrode all animal and vegetable ſubſtances. Theſe curious phænomena had not eſcaped the notice of attentive obſervers of former times; but the honour of firſt ſatisfactorily explaining the true cauſe of theſe events ſeemed reſerved for the illuſtrious profeſſor of chemiſtry at Edinburgh, Dr. Black. He diſcovered, *Dr. Black.*

vered, that by the proceſs of fire, theſe ſubſtances loſt half their former weight, and when treated with acids the compound weighed lighter than before. *Something* therefore was loſt. In a treatiſe, which indeed is a fine ſpecimen of the beſt method of inveſtigating and demonſtrating chemical truths, he aſcertained, "*what this SOMETHING was*;" and proved it to be a permanently elaſtic fluid, which he therefore denominated FIXED AIR, deprived of which, the reſidue was cauſtic or *quick-lime*—having thoſe properties firſt enumerated.

Macbride.

Hitherto the exiſtence of FIXED AIR, and its combination with bodies was a phyſical opinion, and no phyſiologiſt ſince VAN HELMONT had adopted it, when the amiable and learned MACBRIDE, profeſſor of phyſic at Dublin, examined into the medicinal properties of THIS AIR, and eſtabliſhed by the moſt deciſive experiments its *antiſeptic properties*. He aſcertained, that fleſh, which is half putrid, having loſt a portion of the FIXED AIR which enters into its compoſition, may recover its former ſweetneſs, by reſtoring to it its FIXED AIR ; to produce which effect, it will be ſufficient to expoſe it to the vapours of any fermenting ſubſtance, or rather to a current of FIXED AIR from an efferveſcing mixture.

The honourable Mr. Cavendiſh.

Soon after the publication of Dr. MACBRIDE's treatiſe, the Hon. Mr. CAVENDISH communicated to the Royal Society ſome new experiments confirming the doctrines of theſe two eminent profeſſors. He further ſhewed that water is capable of abſorbing a volume of FIXED AIR more than equal to itſelf; that this quantity is proportionably greater as the water is colder, and is compreſſed by a heavier atmoſphere; that water thus impregnated with fixed air has all the acidulous and ſpirituous taſte of Seltzar water. Mr. CAVENDISH added to BOYLE's and HALES' method of obtaining the permanently elaſtic fluids, the modes of confining and transfuſing them from one veſſel to another, ſo that they might be examined and managed with pleaſure, and thus he gave "*to airy nothing a local habitation and a name:*" he determined the quantities of fixed and inflammable gaſes obtained from different ſubſtances: he aſcertained their ſpecific gravities: and introduced, or at leaſt ſet the example, by his accurate mode of experimenting

ing, of eſtabliſhing a complete ſyſtem of *pneumatic chemiſtry*.

Mr. Lane. Mr. LANE diſcovered* that water impregnated with *fixed air* has the property of diſſolving almoſt all metals, and eſpecially iron and zinc; a very ſmall quantity of theſe metals being ſufficient to communicate to water their taſte and virtues.

Dr. Prieſtley. Soon after Dr. PRIESTLEY entered upon his career, and proceeded with ſuch rapidity of ſucceſs, that he attracted the attention of philoſophers of all nations to theſe and ſimilar objects, and excited their emulation in the ſame purſuit; and thereby he has given riſe to ſuch auſpicious conſequences in chemiſtry, that his entry into this branch of experimental philoſophy will be ever conſidered as an æra in the annals of chemiſtry.

It is impoſſible to compreſs his numerous diſcoveries in the limits of a few pages. They fill up ſix volumes; and as the knowledge of the *permanently elaſtic fluids* is the moſt important part of chemiſtry, and has in a manner given to this ſcience an entirely *new appearance*, I would therefore recommend the reader to a careful ſtudy of the whole of this incomparable and entertaining work. I ſhall therefore here confine myſelf ſolely to the account he gives us of his diſcovery of VITAL AIR, which he denominates DEPHLOGISTICATED AIR.

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* This honour is uſually attributed to Dr. PRIESTLEY, as he took the moſt active part in diffuſing this knowledge.

Of the diſcovery of vital air.

On the 1ſt of Auguſt, 1774, I endeavoured, ſays this illuſtrious philoſopher, to extract air from MERCURIUS CALCINATUS PER SE; and I preſently found that, by means of a very large burning-glaſs, an *aerial fluid* was expelled very readily. Having got three or four times as much as the bulk of the materials, I admitted water to it, and found it was not fixed air, becauſe water did not abſorb it. But what ſurpriſed me exceedingly was, "*that when a candle* "*was put into this newly acquired air, the flame,* "*beſides being larger, burnt with conſiderable more* "*ſplendour, and heat, than in common air; and a* "*piece of burnt wood that had any redneſs in it, was* "*rekindled, and burnt away very faſt, reſembling by* "*its crackling noiſe paper that had been dipped in a ſo*"*lution of nitre.*"

I extracted, he adds, in the ſame way, a quantity of *air*, with the very *ſame property*, from the common RED PRECIPITATE, which had been produced by a ſolution of mercury in ſpirit of nitre, and hence I concluded that this peculiar property was derived in both inſtances from *nitrous particles*. I even thought that what was uſually ſold as the MERCURIUS CALCINATUS PER SE was contaminated with *nitrous acid*. However, upon mentioning this ſuſpicion to Mr. Waltire, he furniſhed me with ſome, which he aſſured me was genuine. This being treated in the ſame manner as the former, only by a longer continuance of heat, I extracted much more air from it than from the other. This experiment might have ſatisfied any other; but, being at Paris in the October following, and knowing that there were ſeveral very eminent chemiſts in that place, I did not omit the opportunity, to get an ounce of MERCURIUS CALCINATUS prepared by Monſ. Cadet; of the genuineneſs of which there could not poſſibly be any ſuſpicion; and at the ſame time I frequently mentioned my ſurpriſe at *the kind* of *air* I had got from this preparation to Monſ. LAVOISIER, and ſeveral other philoſophers who honoured me with their notice in that city.

At the ſame time that I had obtained the air above deſcribed from the MERCURIUS CALCINATUS and the RED PRECIPITATE, I alſo procured ſome of the ſame kind from MINIUM, or RED LEAD. As I never made the leaſt ſecret of any thing that I obſerved, I mentioned this experiment *alſo*, to all my philoſophic acquaintance at Paris, and elſewhere; having no idea at that time to what theſe remarkable facts would lead.

The French chemiſts, who had been inattentive to the admirable diſcoveries of Dr. BLACK and Mr. CAVENDISH, were rouſed by the ſtriking phænomena which Dr. PRIESTLEY's diſcoveries preſented. Their minds being prepared by the active and enlightened genius of the age, the ſpark was no ſooner ſtruck, than the moſt brilliant effects began to ſhew themſelves along the French meridian. Never was the paſſion for novelty, now concurring with philoſophical ardour, more happily exerted among the philoſophers of that lively nation, than in the cultivation of this ample field of knowledge, which had been firſt explored, and the richneſs of the ſoil demonſtrated principally by our illuſtrious countrymen, MAYOW, BOYLE, HALES, BLACK, CAVENDISH,

DISH, and PRIESTLEY; of the three laſt of whom I ſhall be joined, by every lover of ſcience, in the wiſh,

Sero in cœlum redeant.

But the efforts of Dr. PRIESTLEY's diſcoveries were not confined to France. They paſſed to every country in Europe, and acroſs the Atlantic. More extenſive in their influence than the commotions of Calabria, they ſpread their better agitations, particularly into Germany, Italy, and Sweden; in which laſt kingdom they met the congenial ſpirit of two illuſtrious chemiſts, BERGMAN and SCHEELE; the *former* diſtinguiſhed by the order, preciſion, and various abilities with which he improved chemiſtry; and the *other* by ſo numerous a train of diſcoveries as could only occur to a man who, like SCHEELE, joined to a profound knowledge of chemiſtry, an intuitive genius, and a laborious zeal. The diſcovery of VITAL AIR, the pride, as it is called, of modern philoſophy, had ſlumbered for more than a century, when this illuſtrious philoſopher drew it forth from nitre, and a variety of other ſubſtances, and called it EMPYREAL AIR, a word which implies, "*formed of the element of fire*," or "*an air pure in the extreme.*"

Bergman.

Scheele.

It is ſingularly curious, that two philoſophers of the preſent day ſhould both, and at the ſame time, and by different proceſſes, diſcover this WONDERFUL GAS, which has thrown light on the whole œconomy of nature, and both of them ignorant of the prior claim of MAYOW, of whoſe book they certainly knew nothing. Dr. PRIESTLEY and Mr. SCHEELE however paid the debt to humanity, being biaſſed by the prevailing opinion of *phlogiſton*, in which they were ſeconded by the ingenious and laborious KIRWAN, who wrote a book expreſsly to ſupport the *old theory*, as it is called.

Kirwan.

At this time the *new*, or *antiphlogiſtic theory* ſprang up in France. It derived its chief origin from LAVOISIER, who had ſoon the felicity of being joined by BERTHOLLET, MORVEAU, ADET, HAZENFRATZ, DE LA PLACE, MONGE, CHAPTAL, FOURCROY, and others, who have united their labours in eſtabliſhing this *new ſyſtem*; which, from ſuch a combination of talents, could not fail of being exhibited with every advantage, and of fixing the attention of the philoſophic world.

Lavoiſier.

Atmoſpheric air ſupports reſpiration

I. They contend, that although the atmoſphere is a vaſt laboratory, in which nature operates im-

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and combuſtion.

menſe analyſes, ſolutions, precipitations, and combinations, although it is the grand receiver, in which all the attenuated and volatilized productions of terreſtrial bodies are received, mingled, agitated, combined, and ſeparated, nevertheleſs the ATMOSPHERIC AIR is the ſame with regard to its *qualities*, being decidedly marked by its *two properties* of ſupporting reſpiration and combuſtion.

The proof of this.

II. A combuſtible body cannot burn without the contact of atmoſpheric air. Thus combuſtion cannot take place in vacuum.

Combuſtion is limited by the quantity of air.

III. A combuſtible body cannot burn in a given quantity of atmoſpheric air, beyond a certain period. An hundred pints of this air contain only 27 pints capable of ſupporting combuſtion; when theſe 27 pints have been *united to* the combuſtible body, the combuſtion ceaſes, as the other 73 pints cannot in any way contribute to its ſupport.

Combuſtion gives the analyſis of common air.

IV. Hence it appears, that ATMOSPHERIC AIR i a compound of *two different airs*;—of theſe two ſubſtances, *one* ſupports reſpiration and combuſtion;

this is termed VITAL AIR: the *other* is the reverſe of it, and is called AZOTIC AIR.

V. Thus a burning body in the air effects a real analyſis of this fluid. It ſeparates from it and abſorbs the VITAL AIR, which augments the weight, and changes the nature of the burning body.

Vital air unites with the combuſtible body.

VI. The AZOTIC AIR which remains is lighter than the atmoſpheric air, extinguiſhes bodies in combuſtion, and kills animals.

The qualities of the reſiduary air.

VII. Combuſtion then conſiſts in the *fixation* and *abſorption* of VITAL AIR by the combuſtible body, by a true decompoſition of the atmoſpheric air.

The true definition of combuſtion.

VIII. A combuſtible body which has burnt in atmoſpheric air, and *abſorbed* all the VITAL AIR to which it is capable of uniting, can burn no longer even in a freſh quantity of air: it has become incombuſtible, and frequently *acid*.

The qualities of the combuſtible body, when burnt.

IX. As many bodies by abſorbing the VITAL AIR are rendered *acid*, hence the term which it has alſo received of OXYGEN AIR, or the ACIDIFYING PRINCIPLE.

The origin of the term oxygen air.

Of the diſengagement of heat and light.

X. There is another intereſting phænomenon in combuſtion, which modern chemiſtry is able to explain; namely, that of the diſengagement of *heat* and *light*.

Combuſtion alſo decompoſes the vital air.

XI. Combuſtion is not confined to the decompoſition of atmoſpheric air by abſorbing one of its principles; for it alſo *decompoſes* the VITAL AIR, by abſorbing, fixing, and rendering more or leſs ſolid, in the combuſtible body, the *oxygen*, or baſe of the vital air, and diſengaging the ſolvent of this baſe, *caloric*, or *heat*, in greater or leſs quantity.

Light and heat component parts of vital air.

XII. It is demonſtrated, that the light which conſtitutes *flame* is contained in the VITAL AIR, of which it is one of the principles; for combuſtible bodies afford much more flame when they burn in vital air, than in atmoſpheric air.

A corollary.

XIII. Hence it follows, that when we burn a combuſtible body, in order to procure *heat* or *light*, as we do to mitigate the rigours of winter, or to chace away the darkneſs of the evening, we obtain theſe from the AIR itſelf in which they enter as principles.

XIV. Now as VITAL AIR only ſerves to ſupport combuſtion, it is eaſy to conceive, that a very combuſtible body, capable of abſorbing the whole of the VITAL AIR, may be employed to determine the proportion of the vital and azotic airs in common air: thus phoſphorus and nitrous air are now uſed for the purpoſe of *eudiometry*, or to diſcover the purity of the air; that is to ſay, the proportion of the VITAL AIR which it contains.

How the goodneſs of common air may be aſcertained.

XV. Combuſtible bodies are too various, numerous, and important in the phænomena they exhibit, and the combinations they are inceſſantly entering into with each other and with the air, not to excite us to examine them with care, and endeavour accurately to aſcertain their properties and ſpecific characters.

Why we ſhould appreciate different combuſtible bodies.

XVI. The diamond is the hardeſt of all the bodies we know. It is very remarkable for the power with which it refracts and decompoſes light, from which the immortal NEWTON rightly conjectured it was combuſtible, and this is found actually to be the caſe *.

The diamond is a combuſtible body.

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* Vide p. 14.

Metals unite with oxygen the baſe of vital air.

XVII. Though there are various circumſtances under which metals may be united with OXYGEN, they may be reduced to three.

1. The firſt is the contact of *air*,
2. The ſecond is owing to the decompoſition of *water*, which we ſhall preſently ſhew is compoſed principally of oxygen,
3. The third depends on *acids*.

In this triple view the oxydation and diſſolution of metals are here to be conſidered.

Metals are to be eſteemed combuſtible bodies.

XVIII. All metals heated in the air, and raiſed to a temperature more or leſs high, are ſuſceptible of burning with a vivid flame, great heat, and a true deflagration, in which proceſs they abſorb OXYGEN. Thoſe that oxydate ſlowly, and without perceptible inflammation, equally diſengage *light* [and *caloric* from the vital air, but in ſo ſmall a quantity at a time, that they are not rendered ſenſible to our organs.

Metals during combuſtion in-

XIX. All metals increaſe their weight during this operation, which does not take place without the contact of air, and conſequently they abſorb a principle, the OXYGEN of the atmoſphere, without loſing any one.

creaſe in weight by abſorbing oxygen.

Neither the name of calcination which was given to this phænomenon, nor that of metallic calces, can be retained; but inſtead of theſe have been ſubſtituted the terms of combuſtion and oxydation for the operation, and of metallic oxyds to denote the metals thus burnt or oxydated.

XX. Elevation of temperature favours the abſorption of the OXYGEN of the atmoſphere by metals, and renders the combination of this principle with theſe combuſtible bodies more conſiderable.

Heat increaſes this abſorption.

XXI. While there are ſome metals which never burn in the air, except at a high temperature, as gold, ſilver, and platina, there are others which burn at all temperatures, even the loweſt, and with great promptitude, as mangneſe. Some, as iron, copper, lead, burn ſlowly, and in the courſe of ſome months, in the air, even though cold.

Metals differ in this reſpect.

XXII. Not only do all metals compared with each other abſorb different quantities of OXYGEN to ſaturate

Metals abſorb different quantities of vital air.

ſaturate them in their combuſtion by the contact of air, but each metal conſidered ſeparately abſorbs different proportions, and ſtops at various points of *oxydation*, according to the degree of temperature to which it is raiſed. Thus tin, lead, copper, iron, change colour and aſſume the tints of the rainbow, at the firſt degree of fire to which they are expoſed in contact with the air: lead firſt becomes a grey oxyd, next yellow, and laſtly red; mercury paſſes from black to white, from white to yellow, and from yellow to red; iron, at firſt a black oxyd, becomes next green, then brown, and ultimately white: copper is at firſt a brown oxyd, from which it changes to blue, and its laſt degree of oxydation imparts to it a green colour.

The reaſon why metals exhibit different coloured flames.

XXIII. The colour which metals diſplay in burning, or with which their flame is tinged, appears to be owing to the diſſolution of the metallic molecules in the light that is evolved. Thus copper yields a green flame, &c.

Before we conſider the oxydation of metals in *water* and *acids*, it may be proper firſt to notice the compoſition of theſe bodies.

XXIV. Water is not a ſimple element, as was formerly ſuppoſed. By burning with rapidity a number of combuſtible bodies, more or leſs heated, as charcoal, red-hot iron, oil, &c. water is decompoſed, yielding to theſe combuſtible bodies the OXYGEN it contained.

Combuſtible bodies decompoſe water, depriving it of its oxygen.

XXV. In proportion as the OXYGEN of the water becomes fixed in the combuſtible bodies which it burns, its other principle which is diſſolved in the caloric forms the INFLAMMABLE AIR which is evolved.

Hence the evolution of its other principle hydrogen.

As this ſecond principle is one of the elements of water, it has been called HYDROGEN, and when it is an elaſtic fluid from its ſolution in light and caloric, HYDROGEN or INFLAMMABLE AIR.

XXVI. Reiterated experiments have proved, that water contains 85 parts in a hundred of OXYGEN, and 15 of HYDROGEN. The recompoſition of water, one of the moſt brilliant diſcoveries of modern chemiſtry, which was made by the Honourable Mr. Cavendish, confirms the analyſis of this body; for on uniting by combuſtion 85 parts of OXYGEN with 15 of HYDROGEN, 100 parts of pure water are obtained.

The compoſition of water proved by ſyntheſis.

XXVII. The

Hydrogen air ariſes always from the decompoſition of water.

XXVII. The HYDROGEN AIR produced in various experiments always originates from water, either in conſequence of a preceding decompoſition, in which it had been combined in the ſtate of *fixed hydrogen*, with one of the ſubſtances employed, or from the decompoſition of the water actually taking place in the experiments themſelves.

All HYDROGEN therefore proceeds from water, and when it is in the form of *air* it has combined with caloric: and it is eaſy to conceive how hydrogen, one of the elements of water, acquires levity by participating of the elaſtic property of caloric: and, in fact, while a cubic foot of water weighs ſeventy pounds, a cubic foot of pure hydrogen air weighs only ſixty-one grains.

Heat aſſiſts the decompoſition of water.

XXVIII. The combuſtible bodies which decompoſe water, generally ſpeaking, are thoſe which have a greater affinity, or ſtronger attraction, for oxygen, than hydrogen has: but this attraction is greatly aſſiſted by the preſence of caloric, which, as we obſerved, united with the hydrogen, holding it in ſolution in the form of gas or air.

The different ſpecies of inflammable air.

XXIX. HYDROGEN GAS carries along with it various ſubſtances, either ſuſpended or diſſolved in it, according as the bodies are applied to the water from whence it is extricated. From the difference of theſe adventitious ſubſtances which it contains, it *varies* in ſmell, weight, and inflammability, the colour of the flame it yields, its action on different bodies, and alſo in the product which it affords in burning. Hence are derived the ſeveral ſpecies and denominations of inflammable air admitted by authors, of which hydrogen always conſtitutes the general baſis.

The properties of hydrogen.

XXX. To recapitulate. HYDROGEN is one of the principles of water. With caloric and light it forms hydrogen air, thirteen times as light as common air, capable of diſſolving ſulphur, phoſphorus, charcoal, oil, &c. and then forming the different ſpecies of hydrogen air, formerly called ſulphurated, phoſphorated, carbonated, oleagenous, inflammable air. It imparts to all the compounds into which it enters, whether they be combuſtible or not, a conſiderable refringent power, which property led the ſagacious NEWTON to conjecture, that a combuſtible ſubſtance was contained in water.

XXXI. The

The cauſe of the aurora borealis.

XXXI. The hydrogen air being thirteen times lighter than common air, it riſes above the common air, and to the combuſtion of this air, by means of the electric fluid, ariſes moſt probably the phænomenon of the aurora borealis.

The cauſe of detonations.

XXXII. The diſengagement of this principle in the form of gas, which takes place wherever water is decompoſed by a combuſtible body, is the cauſe of a great number of detonations and fulminations, which occur in chemical proceſſes.

Of thunder and rain.

XXXIII. It is alſo probable that atmoſpheric detonations, claps of thunder, proceed from the hydrogen air inflaming in common air; and accordingly they are often ſucceeded by a torrent of rain.

Sudden appearance of ſtorm.

XXXIV. When in a clear day a ſtorm on a ſudden takes place, and the heavens are overcaſt, it is probable that this ſudden formation of water in the atmoſphere, ariſes from the rapid union of the hydrogen gas and vital air, occaſioned by the neceſſary reeſtabliſhment of an equilibrium of electricity between different clouds, or between the clouds and the earth.

XXXIV. As every acid contains OXYGEN, and loſes its acidity exactly in proportion as it is deprived of this principle, we ought to conſider acids as burnt or oxydated ſubſtances, which are akin to each other from the preſence of this acidifying principle.

The origin of acids.

XXXV. Since all acids reſemble each other in their taſte, their manner of giving a red colour to vegetable ſubſtances, their tendency to combine with alkalies, and metallic oxyds, and their property of attracting and being attracted powerfully, it was natural to preſume, as Sir Iſaac NEWTON obſerved, that they likewiſe reſembled each other in their intimate nature, and poſſeſſed ſome homogeneal principle: and chemical analyſis has eſtabliſhed this as a truth beyond the poſſibility of a doubt.

Why acids have common properties.

XXXVI. The beſt method of acquiring a knowledge of the nature of acids is by forming them, by compoſing them, from their conſtituent parts, in uniting with OXYGEN ſuch ſubſtances as are capable of becoming acid by an union with it.

Method of inveſtigation.

The advance made in this branch of ſcience.

XXXVII. Out of thirty known ſpecies of acids, there are but three, ſtrictly ſpeaking, which we can either compoſe or decompoſe, ſo that we are neceſſarily ignorant of their nature; but there is no reaſon why we ſhould not regard ſubſtances of this kind as accurately diſcriminated, and contemplate their general properties and compoſitions.

Why acids are differently characteriſed.

XXXVIII. All acids being compounds of OXYGEN with DIFFERENT SUBSTANCES, the *former principle* is the cauſe of their reſemblance and common properties; the *latter*, being different in each, may ſerve to characterize each in particular. For this reaſon, thoſe matters which are variable in acids are termed their baſes, or acidifiable principles.

Of the common principle and baſe.

XXXIX. Thus all acids are combinations of baſes, or acidifiable ſubſtances, different in each ſpecies, with oxygen, which is the ſame in all: whence it follows, that their common properties, their characters as acids, depend on OXYGEN; their particular properties, their ſpecific characters, ariſe from their baſes.

The new nomenclature.

XL. The word acid, indicating the general and identical nature of theſe ſubſtances, forms their generical name, while the particular name of the baſes of each may with propriety deſignate each particular acid. Thus ſulphur is the baſis of the acid we call ſulphurous, carbon that of the carbonic, and ſo on.

Metals decompoſe water.

XLI. Various metals decompoſe WATER, and this the more rapidly the higher the temperature is raiſed. Thus iron decompoſes water with the greateſt rapidity when much heated, though it requires a conſiderable time to effect its decompoſition at the higheſt temperature our atmoſphere ever attains.

Sulphurous acid promotes the decompoſition of water.

LXII. Sulphurous acid, diluted with water, greatly facilitates the decompoſition of the aqueous fluid by means of metals, and evolves in this proceſs hydrogen gas; this is eminently the caſe in the diſſolution of iron or zinc by the diluted ſulphurous acid.

Sometimes acids are alſo decompoſed.

XLIII. There are ſome caſes in which the WATER and the ACID are at the ſame time *decompoſed* by the metal, as in the ſolution of tin in the nitrous acid. Tin is ſo greedy of OXYGEN, and requires ſo large a quantity for its ſaturation, that after having abſorbed that of the nitrous acid, and reduced it to the ſtate of azote, it decompoſes likewiſe the water, and diſengages hydrogen. Theſe two principles being ſeparated from their firſt compounds, unite together, and immediately form ammoniac.

The different affinities which metals have for oxygen.

XLIV. Metallic oxyds have different degrees of affinity with acids; hence ſome may be employed to decompoſe combinations of others. Thus ſeveral metals, by taking OXYGEN from the others which are diſſolved by means of acids, occaſion the re-appearance of the diſſolved metal. Thus mercury will occaſion the re-appearance of ſilver, copper of mercury, iron of copper, zinc of iron, &c.

The reduction of metals.

XLV. The reduction of metals ariſes from ſubſtances which have a greater affinity for OXYGEN than the metallic baſe, and theſe combine and form with this principle different compounds. Thus carbon or charcoal added to a metallic oxyd, at a certain temperature, unites with the OXYGEN of the calx, and forms carbonic acid air, or fixed air, and hydrogen air, by uniting with the OXYGEN of a metallic oxyd, or calx, forms water, while the metal is reſtored to its metallic ſplendour and its other characteriſtic properties*.

The progreſs of the new chemiſtry.

One may here pauſe a moment to conſider the cauſes that pervert the underſtandings of men, and the difficulty there is to root up error when once eſtabliſhed.—It is natural in the rudeſt ſtate of ſcience to conſider the changes of property in chemical bodies as reſulting from the loſs or acquiſition of *ſomething*, and, if this could not be demonſtrated, to give it ſome general appellation. Hence the term PHLOGISTON. It was this principle, which eſcaping from a metal during calcination converted it into a calx, or earthy ſubſtance; and it was the union of this principle which rendered the air mephitic. Here the PHLOGISTIANS appealed to the ſenſes.—But when theſe altered bodies came to be accurately weighed, it was found that 100 pounds of lead converted into minium, or calx of lead, weighed 112 pounds; and when the experiment was performed in cloſe veſſels, the volume of air was diminiſhed during the proceſs; and the air, after the calcination was complete, weighed exactly 12 pounds leſs than before.—This argument, which ſhook the very foundation of the *phlogiſtic doctrine*, the ſophiſtry of men, who wiſhed to indulge their deluſion, endeavoured to anſwer by ſaying, that gravity was relative; thus a cork which falls to the ground riſes in water, and PHLOGISTON having a tendency upwards, buoyed as it were each body in which it entered, and hence, when removed from the metal, its increaſe of weight, and hence the decreaſe of weight in the atmoſpheric air employed in calcination.—When it was obſerved, that this explanation would not hold in other inſtances, for when charcoal was burnt there was but a ſmall reſiduum, and this weighed *lighter* than when it had its phlogiſton, and the mephitic air on the contrary *heavier*, "Ah," ſay they, "there are dif-" ficulties in every ſcience, and we do not preſume "to explain every thing;" generally at this ſame time, knitting the forehead, and walking off.—But the ANTIPHLOGISTIANS kept on exulting at every interview, and they examined the *mephitic air* from each proceſs, and obſerved it was ſometimes *azotic air*, ſometimes when charcoal was uſed *fixed air*, and ſometimes *water*; and when the MERCURIUS PRECIPTATUS PER SE was diſcovered by Monſ. LAVOISIER

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* Many of theſe poſitions are proved by *analyſis* and *ſyntheſis* in PART I. of this work.

SIER to give out VITAL AIR which calcined other metals, giving them weight, and that when any reſidue of this air remained it was not *mephitic*, and when combined with mephitic air in the proportion of one to four it made common atmoſpheric air, it was then that the ANTIPHLOGISTIANS truly triumphed, and the VITAL AIR, which forms a fourth part of our atmoſphere, became the univerſal ŒDIPUS that unlocks all the myſteries of chemiſtry; the *cauſa ſine qua non* of the antiphlogiſtic ſchool.

The *new doctrine* was combated by Dr. BLACK for ten years, who finally became a convert to it. Writing to LAVOISIER, he ſays, "ſuch is the force "of PREJUDICE that it requires ten years to over"come this hydra, but now I feel the force of truth, "and aſſent to it."—The celebrated KIRWAN next writes to LAVOISIER, "that he has renounced his "work in favour of the *phlogiſtic doctrine*, and means "himſelf to refute it." Even Dr. PRIESTLEY declares, "that he has been more than once upon the point of "abandoning the doctrine of *phlogiſton*;" and in his ſixth volume he actually declares "in favour of "the decompoſition of water," and adds, "nor ſhall "I feel much reluctance to adopt the *new doctrine*,

" although I think the chemical phænomena admit " of the eaſieſt explanation on the old ſyſtem."

Reſpecting the nature of the compoſition of the *air* Dr. PRIESTLEY ſays, " for my own part I will frankly " acknowledge, that, at the commencement of the " experiments recited*, I was ſo far from having " formed any hypotheſis that led me to the diſcoveries " theſe produced, that they appeared to me improbable " when I heard of them; and when the deciſive facts " did at length obtrude themſelves upon my notice, it " was very ſlowly, and with great heſitation, that I " yielded to the evidence of my ſenſes. And yet, " when I reconſider the matter, and compare my " laſt diſcoveries relating to the conſtitution of the " atmoſphere with the firſt, I ſee the cloſeſt and " eaſieſt connection between them, ſo as to wonder " that I ſhould not have been led immediately from " the one to the other. That this was not the caſe, " I attribute to the force of PREJUDICE, which, " unknown to ourſelves, biaſſes not only our judg-" ments, properly ſo called, but even the percep-" tions of our ſenſes; for we may take a maxim ſo " ſtrongly for granted, that the plaineſt evidence of

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* Vide page xxix.

" ſenſe will not entirely change, and often hardly " modify, our perſuaſions; and the more ingenious " a man is, the more effectually he is entangled in " his errors; his ingenuity only helping him to deceive himſelf by evading the force of truth."

We will not fatigue the reader by entering more deeply into the *new* or *antiphlogiſtic doctrine* reſpecting thoſe bodies which have no vital principle, and which are therefore diſtinguiſhed as belonging to the mineral kingdom.

The difference between the mineral and vegetable kingdoms.

XLVI. In the *mineral kingdom*, we are juſtified in referring all the phænomena to the action of external bodies, and the ſimple law of affinity affords deductions ſufficient to account for all its changes. In the *vegetable kingdom*, on the contrary, we are compelled to acknowledge a vital principle which preſides over every thing, and performs many chemical proceſſes which we poor mortals attempt in vain to imitate.

Plants are diſtinguiſhed by poſſeſſing a living principle.

XLVII. That plants have a *living principle* is evident by the motion of the ſenſitive plant, which we may excite at pleaſure; by the ſpontaneous motion of the hedyſarum gyrans; the retraction of the ſtamina of the ceſtus; the advance of the ſtamina to the piſtillum in other flowers; by the leaves turning to the light; and ſome plants following the ſun; by their cloſing againſt rain; by the roots turning out of their direction to plunge themſelves into water, or a more favourite ſoil, &c.

They reproduce their ſpecies.

XLVIII. The reproduction of *vegetables* is effected in the ſame manner as that of *animals*; and modern botaniſts have ſupported the compariſon between theſe two functions in the moſt concluſive manner.

Their relation to air.

XLIX. *Vegetables* require the ſame kind of air as *animals*.

They have no locomotive power.

L. The *great difference* which exiſts between *vegetables* and *animals* is, that the latter *in general** are capable of conveying themſelves in ſearch of nouriſhment; whereas vegetables, being fixed in the ſame place, are obliged to take up in their own vicinity all ſuch materials as are capable of nouriſhing them:

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* Oyſters, muſcles, polypi, &c. connect this chain, and ſeem as it were intermediate links, having no locomotive power.

and nature has therefore provided them with leaves, to extract from the atmoſphere the air and water, while the roots extend to a diſtance in the earth to take firm hold, as well as to imbibe water and the fixed air contained within the bowels of the earth.

Dr. Prieſtley's and Dr. Ingenhouz's diſcoveries reſpecting plants.

LI. Dr. PRIESTLEY diſcovered, in the year 1772, that plants emitted VITAL AIR and abſorbed FIXED AIR; for which diſcovery he received the thanks of the *Royal Society*, in an eloquent ſpeech delivered by the preſident, "From your diſcoveries," ſays Sir JOHN PRINGLE, "we are "aſſured, that no vegetable grows in vain, but "that, from the oak of the foreſt, to the graſs in the "field, every individual plant is ſerviceable to man-"kind; if not always diſtinguiſhed by ſome medi-"cinal virtue, yet making a part of the whole, "which cleanſes and purifies our atmoſphere. In "this the fragrant roſe-tree and deadly night-ſhade "co-operate: nor is the herbage, nor woods that "flouriſh in the moſt remote and unpeopled regions, "unprofitable to us, nor we to them, conſidering "how conſtantly the winds convey to them the "FIXED AIR iſſuing from our lungs, while they "ſend out VITAL AIR for us." Mr. SCHEELE having made ſome experiments diametrically oppoſite to this poſition, Dr. PRIESTLEY employed a whole ſummer to repeat his former experiments, and perceived that upon many occaſions AZOTIC AIR was given out, but he confeſſes, "he could not "diſcover the cauſes of this circumſtance." This laurel was reſerved to decorate the brow of the laborious and ingenious Dr INGENHOUZ, phyſician to her Imperial Majeſty. He firſt ſhewed, that the trunk and foliage of plants gave out VITAL AIR only in the preſence of *light*. Hence if you put a plant under water in an inverted tumbler, and expoſe it to the rays of the ſun, in a few minutes air will be given out, and upon examining this, it will be found to be the pureſt VITAL AIR: or if ſucceſſive plants be put into *azotic air*, it will be ſo ameliorated, that combuſtion will be ſupported in it, and it will poſſeſs the nature, and moſt probably the ſame identity, as common air: or if a plant be expoſed under theſe circumſtances to *inflammable air*, it will form a truly exploſive air*. This philoſopher, all

Dr. Ingenhouz's diſcoveries.

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* That inflammable air and vital air when mixed are exploſive, is a very valuable diſcovery, which enabled this philoſopher firſt to give a diſtinct theory of gunpowder, and the wonderful phænomena of earthquakes. Vide his *Nouvelles Experiences et Obſervations ſur divers Objets de Phyſique*, in four volumes octavo.

whoſe experiments are exceedingly elegant, and whoſe apparatus is the ſimpleſt imaginable, and his narrative the eaſy flowing of a ſagacious mind intent upon the truth, at the ſame time diſcovered that in *the abſence* of *light*, not VITAL, but AZOTIC and FIXED, AIRS* were given out; and that even during the ſunſhine flowers, roots, and ripe fruit, always produced theſe deleterious airs. Hence he taught us the true relation we ſtand in with regard to the *vegetable race*, and he has alſo extended theſe curious and beautiful reſearches by aſcertaining the different proportions of VITAL AIR to the AZOTIC AIR in different ſituations, and has demonſtrated, that in a given quantity of atmoſpheric air, "there is more VITAL AIR in the country than "in towns; and more near the ſea than inland;" nevertheleſs he found by his *eudiometer*, "leſs in the "marſhy lands of *Holland* than at *Vienna*, and he "attributes *the keenneſs of appetite, and quickneſs of di-* "*geſtion, in the latter place, to this circumſtance.*" He formed great expectation of the VITAL AIR in diſeaſes, and after inhaling it himſelf, "he experi-"enced," he ſays, "a remarkable *alacrity* of *mind* "and *body*, and thinks he *ſlept ſounder* than *uſual* that "night." He was the firſt who adminiſtered the VITAL AIR in ASTHMA, and he has had the honour of giving it to the ARCHDUCHESS OF RUSSIA, who alſo experienced the ſame benign effects as this philoſopher*.

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* If we caſt our regards with aſtoniſhment on the vaſt ſcene of that perpetual rotation of organized beings; when we conſider that all living animals, by their reſpiration, perſpiration, digeſtion of food, by the putrid fermentation of their bodies after death; that all vegetables as long as they live, as well as when they are in a ſtate of decompoſition after death; that in combuſtion, and, in ſhort, in an infinite variety of operations, every where obvious on the ſurface of the earth, they have one general effect, that of producing carbonic acid, or FIXED AIR; if we conſider, I ſay, that all theſe conſpire, as it were, in forming this compound ſubſtance (carbon and oxygen), is it poſſible to doubt that this fluid, the carbonic acid or fixed air, has an utility as extenſive as its almoſt univerſal production?

But it may be aſked, why is not *this air* to be found in the atmoſphere? The ſolution is given us by this admirable philoſopher himſelf. "This union of CARBON and OXYGEN in the ſtate of air, having a greater *ſpecific gravity* than atmoſpheric air, quits, almoſt as ſoon as it is generated, the common ſtock, ſinks to the ground, and being eaſily miſcible with water, percolates through the ground to become the food of plants, and in the rays of the ſun is decompoſed, ſupplying them with their *carbon*, or wood. Thus 3 cubic inches of a *triplex laciniata* in common water produced in ſix hours in bright ſunſhine 3 meaſures of VITAL AIR, quality 228; whereas in ſtrongly aerated water it produced 9½, and whoſe quality above atmoſpheric air was 286." Dr. INGENHOUZ alſo diſcovered that common air was abſorbed by plants as well as water, which in the ſunſhine were decompoſed and gave out their common principle, viz. VITAL AIR. See his ingenious Diſſertation *on the Food of Plants*, preſented to THE BOARD OF AGRICULTURE, and printed by their order; and his *Experiments on Plants*, which were firſt publiſhed in Engliſh, and afterwards in French.

Dr. Ingenhouz's experience with regard to vital air.

LII. When

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* In 1779 Dr. INGENHOUZ diſcovered that the animal body threw out AZOTIC, and FIXED, AIRS. In the very ſame year Mr. CRUIKSHANK,

Dr. Prieſtley's experience.

LII. When Dr. Priestley inhaled the VITAL AIR, he felt for ſome time afterwards "his *breaſt* peculiarly *light* and *eaſy*." He conjectures from the greater ſtrength and vivacity of the flame of a candle in VITAL AIR, "that it might be peculiarly ſalutary "in all caſes of weakneſs, or a want of energy in the "ſyſtem.—Hitherto," he adds, "only two mice and "myſelf have had the privilege of breathing it."

Speaking of *factitious airs* in general, he ſays, "I "cannot help flattering myſelf, that, in time, very "great medicinal uſe will be made of the application "of theſe different kinds of air to the animal ſyſtem. "Let INGENIOUS PHYSICIANS attend to this "ſubject, and lay hold of the *new handle*, which is "now preſented them, before it be ſeized on by "RASH EMPIRICS; who, by an indiſcriminate "and injudicious application, often ruin the credit

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Cruikshank, the celebrated author of a work on the Abſorbent Syſtem, and lecturer on Anatomy in London, publiſhed a ſimilar diſcovery, and in juſtice to both characters, I muſt obſerve, that their reſpective works were in the preſs at the ſame time. This however is not the only inſtance of two perſons, ignorant of each others purſuits, happening to hit upon the ſame thing (vide page l.). Mr. Cruikshank has extended this diſcovery to the phænomena of *reſpiration*, and a more accurate inveſtigation may hereafter perhaps determine for this philoſopher the honour of a ſtill more IMPORTANT DISCOVERY. Vide Vol. II. page 277.

"of things and proceſſes, which might otherwiſe "make an uſeful addition to the materia and ars "medica."

The effects of fixed air.

Dr. Percival's experience.

Dr. Smith's important diſcovery.

LIII. It is not in the order of this work to trace here minutely the progreſs of the *pneumatic practice* of phyſic, we ſhall therefore paſs over the teſtimonies of Dr. PERCIVAL, &c. reſpecting the ſalutary effects of FIXED AIR in conſumption, mortification, and ulcers, and haſten briefly to record the introduction of the OXYGENATED NITROUS ACID VAPOURS, for arreſting the progreſs of *contagious fever*.

The efficacy of the nitrous acid vapour in arreſting peſtilential fever.

In the year 1782 an infectious fever broke out among the priſoners in *Wincheſter*. This excited the attention of Parliament, and many eminent phyſicians in London were applied to, to take charge of the priſoners there; but they refuſed venturing upon ſo hazardous an office. The late Dr. FOTHERGILL then waited on Dr. SMITH, and requeſted him, in the moſt urgent manner, to accompany the commiſſioner to Wincheſter. Two hundred and forty perſons had already periſhed by this dreadful malady, whoſe violence ſeemed daily increaſing. Moſt of the officers and ſervants belonging to the hoſpital had fallen victims to this fatal diſtemper. But ſuch was the powerful influence of the NITROUS ACID VAPOUR, the number was reduced to 9, 5, 3, and 2,—and afterwards none died Dr. CARMICHAEL SMITH himſelf was ſeized with this diſorder, and confined to his bed, yet, like a true hero, he would not yield to his diſeaſe, but continued to give directions. In a memorial which he afterwards ſent to the miniſter of ſtate, in mentioning theſe circumſtances, he ſays, " But theſe, my lord, are only " the ſufferings of an individual. I readily com- " plied with your lordſhip's wiſhes, and as to the " conditions of my attendance I made none: con- " vinced that no pecuniary recompence could be an " adequate compenſation to me, circumſtanced as I " then was, for the riſk I ran ; and that if I was for- " tunate enough to ſurvive, and *ſucceed*, I was cer- " tain of the firſt of all rewards, the *conſciouſneſs* of " having *diſcharged* a *duty* to which I was *called* by the " *voice* of *my country*, and in the event of which the " national as well as my own honour was involved. " My endeavours have been attended with a ſucceſs "which even my friends could hardly expect, and "which I believe ſtands *without example* in the annals of phyſic. I have already received from the "*public* the fulleſt approbation of my conduct, and "make no doubt that, in conſequence of your lordſhip's favourable repreſentation of it to the *king*, I "ſhall receive from *his majeſty*, ever attentive to reward merit in the loweſt of his ſubjects, ſome "mark of his Majeſty's royal favour." In conſequence of which diſcovery, he was appointed phyſician extraordinary to the king.

This *antiſeptic vapour* was afterwards applied, in the year 1795, by the order of the lords commiſſioners of the Admiralty, on board the Union hoſpital ſhip, and with the ſame happy ſucceſs *.

De Morveau.

LIII. Near about the ſame time in *France* a very important diſcovery was made. Monſ. DE MORVEAU, the aſſociate of LAVOISIER and FOURCROY, employed for the ſame purpoſe the OXYGENATED MARINE ACID in the form of air, or vapour, and purified the infected hoſpital at Dijon. This method was afterwards extended to the different military hoſpitals by a decree of the national aſſembly.

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* Vide *An Account of the Experiment made on board the Union Hoſpital-Ship, to determine the Effect of the Nitrous Acid Vapour in deſtroying Contagion, in a Letter addreſſed to the Right Hon. Earl Spencer.* By James Carmichael SMITH, M. D.

LIV. Since there is no diſorder to which human nature is ſubject, more deſtructive or alarming than contagious fever, the humane reader will not require an apology for delaying his attention upon ſo important a point, more eſpecially as it confers the higheſt honour on the preſent enlightened age, and holds out a proſpect that one of the greateſt ſcourges to mankind will be at laſt baniſhed from the earth, never again to rear its truly formidable head.

Dr. Crawford's diſcovery.

LV. As Dr. CRAWFORD, brother to the late celebrated Dr. ADAIR CRAWFORD, of whom we may juſtly ſay,

——————Par nobile fratrum,

was returning to England from India, in the year 1770, on board the Earl of Middleſex, an epidemic fever broke out among the crew, which ſeemed to threaten an alarming mortality*. Thirty of the men were ſeized with the characteriſtic ſymptoms of this diſeaſe. Three of the unhappy ſufferers early periſhed. On each ſide the eye was now ſaddened with the deſpondence which was viſible in every countenance: and the ear was diſtracted with the groans and difficult reſpiration of thoſe who ſuffered, or by the foreboding of ſuch as had hitherto eſcaped. Nor was the ſituation of this compaſſionate phyſician leſs lamentable than the reſt. The uplifted eye implored for help in vain! He had no clue to conduct him in his preſent difficulty. But the man of ſcience does not ſoon yield up to deſpair. He inveſtigates the hidden cauſes of diſeaſe, and Nature in her bounty not unfrequently bleſſes the laudable endeavour. From the accurate and ingenious experiments of Dr. ADAIR CRAWFORD, it appears, that when an animal is immerſed in hot water, the veins pour out upon veneſection, not a black, but florid, blood; and other obſervers have alſo noticed, that blood taken from the arm in ſummer is of a brighter hue than in winter. Hence it is reaſonable to ſuppoſe, that as the liver is an organ deſtined by nature to receive black, or venal blood, that this dark blood is intended to be a ſufficient ſtimulus; but when, on the contrary, that organ receives florid or arterial blood, that the ſtimulus is then too great, and inflammation of that viſcus enſues. Perhaps under this perſuaſion (for the Earl of Middleſex was now near the tropic), or from its acknowledged utility, Dr. CRAWFORD opened one of the dead bodies, and had a demonſtrative proof that the liver was the chief ſeat of the preſent diſeaſe. It was not only enlarged, but externally ſhewed a *florid* appearance. Upon this diſcovery he had inſtant recourſe to bleeding and mercurial cathartics, and he obſerved, that where the mercury produced *ſalivation* the recovery was more ſtriking, and he therefore exhibited mercury alſo with this intention.

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* For an account of this fever, vide *An Eſſay on Fever accompanied with a Diſeaſe of the Liver, hitherto but little known, though very frequent and fatal in warm Climates.* A new edition of this very intereſting work is now printing for Kearſley.

On the 20th of May this fever attacked John MASON, a ſtrong athletic ſailor. I ordered, ſays Dr. CRAWFORD, ſixteen ounces of blood to be taken from him. The pulſe roſe immediately in fulneſs, and his reſpiration became eaſy. Three of the aperient pills (theſe were compoſed of mercury, aloes, ſoap, and jalap) were adminiſtered, and the ſame quantity repeated in the evening, which produced a ſufficient effect. Theſe were continued each day, ſo that he had taken now about half a drachm of calomel. On the 25th, his mouth was a good deal affected, and all uneaſineſs in breathing was inſtantly removed. On the 27th the ſalivation abated conſiderably, when his reſpiration became proportionably oppreſſed, he therefore returned to the uſe of the pills. On the 28th the ſalivary diſcharge was again abundant, and it is not a little remarkable, Dr. CRAWFORD adds, " that as " this increaſed, the difficulty of breathing, and all " the other ſymptoms of the diſeaſe, diminiſhed." This obſervation led me, he adds, to keep up the ſpitting for a few days, at the ſame time care was taken to prevent it from being too copious *. On the 29th, 30th, and 31ſt, the ſoreneſs of the mouth was the only diſeaſe, and this decreaſing, the ſailor was ſoon reſtored to ſound health.

Dr. Wade's and Dr. Chiſholm's experience.

LVI. This practice has been ſince purſued with equal ſucceſs by Dr. WADE, in Bengal, in the year 1791, and by Dr. CHISHOLM in the iſland of Grenada, for the cure of the yellow, or bilious autumnal, fever. Dr. WADE did not loſe one patient, and

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* When violent ſalivation came on, this able practitioner had recourſe to opium. This often occaſioned violent torment in the bowels, which was as inſtantly removed by juice of limes. Pleaſe here to conſult Vol. III. page 639.

Dr. **Chisholm** loſt only one out of forty-eight patients in whom the mercury affected the ſalivary glands. The latter gave 150 grains of calomel, and applied the ſtrongeſt mercurial ointment below the groin on each ſide in ſeveral caſes. He declares, that not only the cure was ſpeedy, but that not a ſingle relapſe occurred where the fever was cured by *ſalivation.*

Dr. Ruſh's experience.

LVII. I preſcribed, ſays Dr. Rush, ſpeaking of the late peſtilential fever in Philadelphia [*], bark in large quantities; in one caſe I ordered it to be injected into the bowels every four hours. I directed buckets full of cold water to be thrown frequently upon my patients. The bark was offenſive to the ſtomach, or rejected by it, in every caſe in which I preſcribed it. The cold bath proved grateful, but no otherwiſe ſalutary. Three out of four of my patients died to whom the cold bath was adminiſtered in addition to the tonic remedies before mentioned. Baffled in every attempt to ſtop the ravages of this fever, I anticipated all the numerous and complicated diſtreſſes in our city, which peſtilential diſeaſes have ſo often produced in other countries. The fever had a malignity, and an obſtinacy which I had never before obſerved in any diſeaſe, and it ſpread with a rapidity and mortality, far beyond what it did in the year 1762. Neverthelefs I did not abandon a hope that the diſeaſe was curable, for I had long believed that good was commenſurate with evil, and that there does not exiſt a malady, but would yield to our knowledge of the laws of the animal œconomy. Under the impreſſion of this belief, I applied myſelf with freſh ardour to the inveſtigation of the preſent diſeaſe. I ranſacked my library, and pored over every book that treated of the yellow fever. The reſult of my reſearches for a while were fruitleſs. The accounts of the ſymptoms and cure of the diſeaſe, by the authors I conſulted, were contradictory and uncertain. Before I deſiſted from the inquiry to which I had devoted myſelf, I recollected that I had, among ſome old papers, a MS. account of the yellow fever as it prevailed in Virginia in the year 1741, which had been put into my hands by Dr. FRANKLIN, a very ſhort time before his death. I had

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[*] Vide Dr. Rush's account of the bilious remitting yellow fever, as it appeared in the city of Philadelphia in the year 1793. Alſo Vol. II. page 174, where the hiſtory of this fever is given, and its *relation* to the *ſtate* of the *atmoſphere* is ſet forth.

I had read it formerly, and made extracts from it. I now read it a ſecond time. I pauſed upon every ſentence; even words in ſome places arreſted and fixed my attention. In reading the hiſtory of the effects of different modes of treatment, I was much ſtruck with the following paſſages.

" It muſt be carefully noted, that *evacuations* are " more neceſſary in the yellow fever, than even in " the inflammatory. The abdominal viſcera are the " parts principally affected in this diſeaſe,—and by " this timely evacuation, their feculent, corruptible, " and irritating contents are diſcharged before they " overpower the whole conſtitution. They always " require ſome *evacuation* to bring them to a perfect " criſis. Where the primæ viæ, but eſpecially the " ſtomach, is loaded with the poiſon of the contagion, " and convulſed with the irritation of this ſtimulus, " there is no procuring a deſirable ſweat, " until this is removed. Alſo by *evacuating* the " bowels, the ſeeds of the diſeaſe, which is mixed " with the bilious and inguiline matters in the intestinal " canal is nipped in its birth, and a breathing " ſweat then breaks out of its own accord. I can " affirm, that I have often given *evacuants*, when "the pulſe has been ſo low that it could be hardly "felt, and the debility extreme, yet both one and "the other have been reſtored by it."

In my attendance upon the military hoſpitals during the late war, I had often ſeen, continues Dr. Ruſh, calomel combined with jalap adminiſtered in the bilious autumnal fever by Dr. YOUNG. His uſual doſe was ten grains of each of them. This was given once or twice a-day, until it procured large evacuations from the bowels. It was adopted by ſeveral of the ſurgeons of the hoſpitals, and was univerſally known, and ſometimes preſcribed, by the ſimple name of *ten* and *ten*. I reſolved therefore, after mature deliberation, to preſcribe this purge in the preſent fever. Finding ten grains of jalap inſufficient to carry the calomel through the bowels in the rapid manner I wiſhed, I added fifteen grains of the former to ten of the latter. I then iſſued three doſes, each conſiſting of fifteen grains of jalap, and ten of calomel; one to be given every ſix hours until they procured four or five large evacuations. The effect of this powder not only anſwered, but far exceeded my moſt ſanguine expectations. It perfectly cured four out of the firſt five patients to whom I gave it, notwithſtanding ſome of them were advanced ſeveral days in the diſorder! Mr. Richard Spain, a blockmaker, in Third-ſtreet, took eighty grains of calomel, or rather more, with rhubarb and jalap mixed with it, on the laſt day of Auguſt, and on the firſt day of September. He had paſſed twelve hours, before I began to give him this medicine, without a pulſe, and with a cold ſweat on all his limbs. His relations had given him over, and one of his neighbours complained to me, of my not adviſing them to make preparation for his funeral. But in this awful ſituation I nevertheleſs gave them hopes. My medicine operated well. His pulſe immediately roſe, and an univerſal moiſture on his ſkin ſucceeded the cold ſweats on his limbs. In a few days he was out of danger, and he now lives in good health, as the firſt fruits of the efficacy of *mercurial purges* in the yellow fever. After ſuch a pledge of the ſafety and ſucceſs of my new medicine, I gave it afterwards with confidence. I imparted the preſcription to the college of phyſicians on the third of September, and endeavoured to remove the fears of my fellow citizens, by aſſuring them that the diſeaſe was no longer *incurable*. Mr. Lewis, Dr. M'Ilvaine, Mrs. Bethel, her two ſons, and a ſervant-maid, and Mr. Baynton's whole family, nine in number, were ſome of the firſt trophies of this *new* remedy. The credit it acquired brought me an immenſe acceſſion of buſineſs. It was uniformly effectual in all whom I attended, either in my own perſon, or by my pupils. Dr. GRIFFITH, Dr. SAY, Dr. PENNINGTON, and my former pupils who were ſettled in the city, Drs. LEIB, PORTER, ANNAN, WOODHOUSE, and MEAR, were among the firſt phyſicians who adopted it. In my note-book I put down, "Thank God! "out of one hundred patients, whom I have viſit-"ed, or preſcribed for, this day, I have loſt *none*;" nor ſhall I ever forget the tranſport with which Dr. PENNINGTON ran acroſs the ſtreet to inform me, a few days after he began to give ſtrong purges, that the diſeaſe yielded in every inſtance.—But I did not rely on purging alone to cure the diſeaſe. Conceiving it to depend upon a morbid *ſtimulus* acting upon and overpowering the ſyſtem, I was led to uſe thoſe remedies which we know abſtract ſtimuli in general. Theſe were blood-letting, cool air, cold, watery, and ſub-acid drinks, low diet, and the application of cold water to the body. My ſucceſs with this practice was beyond meaſure great, never before did I experience ſuch ſublime joy. It repaid me for all the toils and ſtudies of my life: and the conqueſt of this diſeaſe was not the effect of accident, nor of the application of a ſingle remedy; but it was the triumph of a PRINCIPLE in *Medicine!*

" During the courſe of my extenſive practice, the " exhibition of calomel purges produces frequently " *ſalivation.* By this accidental effect of mercury I " was taught to adminiſter it with other views, than " merely to cleanſe the bowels, and with a ſucceſs " which added much to my confidence in the power " that this medicine has over the diſeaſe [*]. I began " by preſcribing the calomel in ſmall doſes, at ſhort " intervals, and afterwards I directed large quantities " of the ointment to be rubbed upon the limbs. The " effects of it, in every caſe where the mouth was affected, was very ſalutary and ſpeedy, and even ſeveral perſons appeared to be benefited by the mercury introduced in the ſyſtem in the form of an " ointment, where it did not produce ſalivation. In

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[*] Vide Vol. III. page 650, where mercury is ſhewn to be a cure of *hydrophobia,* and hereafter it may be found to be the ſovereign antidote againſt all other animal and moſt vegetable poiſons.

" the loweſt ſtage of the fever I ordered, in one caſe,
" an ounce of mercurial ointment to be rubbed in.
" The next day the gentleman complained of a ſore
" mouth, and in the courſe of twenty-four hours he
" was in a moderate ſalivation. From this time, his
" pulſe became full and ſlow, and his ſkin moiſt. His
" ſleep and appetite ſuddenly returned, and in a day or
" two he was out of danger. Dr. Woodhouse improved upon Dr. Rush's method of exciting ſalivation, by rubbing the gums and inſide of the cheeks
" with calomel, in the manner directed by Mr. *Clare*,
" and it was obſerved to be more ſpeedy in its operation this way, and equally ſucceſsful."

Dr. Wood's diſcovery.

LVIII. Since the diſcovery, that mercurial oxyds (mercury combined with OXYGEN) is of great efficacy in the cure of putrid fever, another remedy has been much recommended by Dr. Wood. " From
" the accurate obſervations, which have been lately
" made," ſays this ingenious phyſician, "on the effects
" of VITAL AIR on the blood, both in the ſtate
" of circulation, and when drawn from a vein, and
" allowed to cool; from the difference of colour of
" the returning blood, with that which has juſt paſſed

" ed through the lungs; and from our knowledge, " that the red globules are oxydes; and from the " ſimilar appearance, which the blood, in a perſon " labouring under typhus, has with the returning " venous blood; and from the anxiety of reſpiration, " which they who labour under typhus fever always " diſcover,—we can have little doubt, I think, for " ſuppoſing that the deficiency of OXYGEN is the " cauſe of the ſymptoms of typhus, the principal of " which are, beſides thoſe above mentioned, universal debility, and a rapid tendency to a putreſcent " ſtate. Hence we may conclude that OXYGEN " is the general and only corrector of this ſtate, that " it is the grand antiſeptic of nature, and therefore " with the decreaſe of OXYGEN, will increaſe " the tendency to putrefaction, and with the increaſe of the tendency to putrefaction, will the " *irritability* be exhauſted, and ſymptoms of *debility*, " in both body and mind, be progreſſively evident. " The proximate cauſe of typhus fever can therefore " only be removed, as muſt appear from what has " preceded, by the application of OXYGEN in a " ſufficient quantity to correct this deficiency, and " to reſtore the ſtate of equilibrium. OXYGEN

" taken into the ſtomach in the combined ſtate of " many different *acids*[*], may anſwer this intention; " but in the ſtate of *nitre*[†] it ſeems to me the moſt " powerful form of exhibiting it; the proceſs for " obtaining OXYGEN in the ſtate of *gas*, in order " to throw it into the ſyſtem by the lungs, is not " only tedious but difficult. In the ſtate, therefore, " of combination with *nitre*, it appears to me at preſent " the moſt effectual mode of throwing it into " the ſyſtem. I have lately, continues Dr. WOOD, " exhibited *nitre* to more than fifty patients labouring " under typhus; many of whom, when I ſaw them, " had all the ſymptoms of this diſeaſe in a moſt violent " degree. I did not give any previous antimonial; " but I exhibited immediately the ſolution of " *nitre*. In ſome of the patients, the pulſe which " was from 100 to 130 was diminiſhed in frequency, " and increaſed in ſtrength, before the expi-

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[*] The yellow fever prevailed at the Caraceos, in South America, in October 1793, with great mortality. Nearly all died who were attended by phyſicians. Recourſe was finally had to an old woman. Her remedy was a liquor called narencado, a ſpecies of *lemonade*. With this ſhe drenched her patients for the firſt two or three days. It induced plentiful ſweats, and probably, after correcting, diſcharged the acrimony of the bowels.—Dr. RUSH.

[†] Vide Vol. I. page 44.

" ration of the firſt 24 hours; the change, indeed, " was often ſo great and ſudden, that I could ſcarcely " credit my own ſenſes, until repeated experience " ſtampt the firmeſt conviction upon my mind. " Previous to the practice which I now purſue, I " never viſited in typhus, without experiencing ſome " of thoſe feelings, which the phyſician is obliged to " ſuffer, who expects an unſucceſsful iſſue; but now " I have no fears, and I truſt that one of the moſt " crowded avenues to the grave is at length cloſed, " and, judging from the rapid progreſs acquired in the " knowledge of philoſophy and medicine within a " very few late years, I may venture to predict, " that, by ſimilar attempts, every diſeaſe, whoſe " nature is at preſent obſcure, will be at laſt clearly " explained, and the profeſſors of medicine be finally " in poſſeſſion of the *ne plus ultra* of their ſcience."

Rev. Mr. Cartwright's diſcovery.

LIX. In theſe trials the *vital principle* was attempted to be reſtored as faſt as it was conſumed by the exceſſive ſtimulus of the contagious matter taken into the ſyſtem, and producing the putrid fever, or this ſtimulus was attempted to be evacuated; but this enlightened age has alſo produced another philoſophical method, namely, its *correction.* "Seventeen years ago I went," ſays the Rev. Mr. CARTWRIGHT, "to reſide at Brampton, a very populous "village near Cheſterfield. I had not been there "many months before a putrid fever broke out "among us. Finding by far the greater number of "my new pariſhioners much too poor to afford "themſelves medical aſſiſtance, I undertook, by the "help of ſuch books on the ſubject of medicine as "were in my poſſeſſion, to preſcribe for them. I "early attended a boy about fourteen years of age, "who was attacked by this fever. He had not been "ill many days before the ſymptoms were unequivocally putrid. I then adminiſtered bark, wine, and "ſuch other remedies as my books directed. My "exertions however were of no avail; his diſorder "grew every day more untractable and malignant, "ſo that I was in hourly expectation of his diſſolution. Being under the abſolute neceſſity of taking "a journey, before I ſet off I went to ſee him, as I "thought for the laſt time, and I prepared his parents for the event of his death, which I conſidered "as inevitable, and reconciled them in the beſt "manner I was able, to a loſs which I knew they

" would feel ſeverely. While I was in converſation " on this diſtreſſing ſubject with his mother, I ob- " ſerved in a corner of a room a ſmall tub of wort " working. The ſight brought to my recollection " an experiment I had ſomewhere met with, *of a* " *piece of putrid meat being made ſweet by being* " *ſuſpended over a tub of wort in the act of fermenta-* " *tion.* The idea inſtantly *flaſhed* into my mind " that the *yeaſt* might correct the putrid nature of " this diſeaſe, and I inſtantly gave him two large " ſpoonfuls. I then told the mother, if ſhe found " her ſon better, to repeat this doſe every three " hours. I then ſet out for my journey. Upon my " return after a few days I anxiouſly enquired about " the boy, and was informed he was recovered. I " could not repreſs my curioſity, though I was " greatly fatigued with my journey, and night was " come on; I went directly to where he lived, which " was three miles off in a wild part of the moors. " The boy himſelf opened the door, looked ſur- " priſingly well, and told me he felt better from the " inſtant he took the yeaſt.

" After I left Brampton I lived in Leiceſterſhire. " My pariſhioners being there few and opulent I

"dropped my medical character entirely, and would
"not even preſcribe for any of my own family.
"One of my domeſtics falling ill, accordingly the
"apothecary was ſent for. His complaint was a
"violent fever, which in its progreſs became putrid.
"Having great reliance, and deſervedly, on the
"apothecary's penetration and judgment, the man
"was left ſolely to his management. His diſorder
"however kept daily gaining ground, till at length
"the apothecary conſidered him in very great danger.
"At laſt, finding every effort to be of ſervice to him
"baffled, he told me he conſidered it as a loſt caſe,
"and that, in his opinion, the man could not ſur-
"vive four and twenty hours. On the apothecary
"thus giving him up, I determined to try the effects
"of *yeaſt*. I gave him two large table ſpoonsful.
"In fifteen minutes from taking the yeaſt his pulſe,
"though ſtill feeble, began to get compoſed and full.
"He, in thirty-two minutes from his taking the
"yeaſt, was able to get up from his bed, and walk
"in his room. At the expiration of the ſecond
"hour, I gave him a baſon of ſago, with a good
"deal of *lemon*, wine, and ginger in it; he eat it
"with an appetite: in another hour I repeated the

" yeaſt: an hour afterwards I gave the bark as be-
" fore: at the next hour he had food: next he had
" another doſe of yeaſt, and then went to bed, it was
" nine o'clock. I went to ſee him the next morning
" at ſix o'clock; he told me he had a good night,
" and was recovered. I however repeated the medi-
" cine, and he was able to go about his buſineſs as
" uſual.

" About a year after this, as I was riding paſt a
" detached farm-houſe at the out-ſkirts of the village,
" I obſerved a farmer's daughter ſtanding at the door,
" apparently in great affliction. On enquiring into
" the cauſe of her diſtreſs, ſhe told me her father
" was dying. I diſmounted and went into the houſe
" to ſee him. I found him in the laſt ſtage of a
" putrid fever; his tongue was black; his pulſe was
" ſcarcely perceptible; and he lay ſtretched out, like
" a corpſe, in a ſtate of drowſy inſenſibility. I im-
" mediately procured ſome *yeaſt*, which I diluted
" with water, and poured it down his throat. I then
" left him with little hopes of recovery. I returned
" to him in about two hours, and found him ſenſible
" and able to converſe. I then gave him a doſe of
" bark. He afterwards took at a proper interval ſome

" refreſhment. I ſtaid with him till he repeated the " yeaſt, and then left him with directions how to " proceed. I called upon him the next morning at " nine o'clock. I found him apparently well, walk" ing in his garden. He was an old man, upwards " of ſeventy.

" I have ſince adminiſtered the yeaſt to above fifty " perſons labouring under putrid fever, and what is " ſingular, continues this benevolent clergyman, I " have not loſt one patient."

Dr. Thornton's practice in putrid fever.

LX. Another method of cure, combining all the three foregoing, is that adopted by Dr. THORNTON, and recorded by the Rev. Mr. TOWNSEND in *the Guide to Health**. Dr. THORNTON conſiders the contagious matter, productive of putrid fever, as a violent ſtimulus, which reſembles the operation of wine † or opium ‡, firſt increaſing the action of the heart and arteries, and after a few days, having worn down the excitability, the ſthenic diatheſis is ſucceeded by the aſthenic or putrid. He therefore adviſes to *expel* this morbid and exceſſive ſtimulus by evacuations*; ſecondly, to *correct* this ſtimulus, which may be accompliſhed by antiſeptics †; and thirdly, to *ſupply the principle of irritability*, which may be done by oxyds, or the inhalation of factitious vital air.

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* This admirable popular work treats of *the ſymptoms and nature of diſeaſes, and their cure*; and is compriſed in two volumes octavo.

† I once ſaw an inſtance, ſays Dr. BEDDOES, in which I could not doubt that complete *intoxication* was produced by the contagion of typhus, to which the perſon had been much expoſed. One morning, immediately upon riſing, and I knew he had drank nothing the night before, I was aſtoniſhed to obſerve that flighty vivacity and diſpoſition to wild disjointed talk,

" When my phyſician, Dr. THORNTON," ſays the Rev. Mr. *Townſend*, " who had recovered me, " when in the worſt ſtage of a putrid fever, was re" turned to town, he was called in for his advice,

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talk, together with the other ſigns which infallibly denote a certain degree of intoxication, eſpecially when you are well acquainted beforehand with the manners of the party. In the courſe of the day, during which I ſaw him frequently, he became heavy, had febrile ſhiverings, and complained of head-ach. The next day he became more feveriſh, but was not confined till the fifth day, though the head-ach and other ſymptoms never quitted him. He then paſſed into putrid fever, which continued until the 21ſt day, when he recovered. Does not the alkaline urine in ſuch perſons denote, continues Dr. BEDDOES, a deficiency of the oxygen?

‡ Vide Vol. III. page 625. Sect. LII. *Of Aſphyxia from opium.*

* During the late war in America an *emetic* ſeldom failed of preventing an attack of putrid fever when given in its forming ſtage. Vide RUSH *on the Yellow Fever*, page 336.

† Chiefly ſuch as impart *fixed air.*

" reſpecting two children labouring under the ſame " ſpecies of fever. As the eldeſt child appeared to " be in the greateſt danger, with a becoming diffi- " dence of a *new practice* *, he deſired the father to " allow him to accept her only as his patient, and " that the apothecary ſhould go on with the young- " eſt. He gave inſtantly an emetic of tartarized an- " timony and ipecacuanha; and after the operation " was fully over, and a litle nouriſhment got down, " he followed it up with rhubarb and tartarized kali, " ſupporting the patient at intervals with wine. " When the bowels were clear he ordered at regular " intervals an infuſion of bark in port wine impreg- " nated with FIXED AIR, and her drink was wa- " ter acidulated with FIXED AIR and tamarinds. " Mild cathartics were exhibited each night, and the " antiſeptic remedies were leſſened, and his patient " inhaled air blended with factitious VITAL AIR. " Dr. THORNTON then went into the country to " ſee ſome particular friends, and on his return he " haſtened to viſit theſe children. He found his " little patient in perfect health and blooming; but

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* *Evacuations* in putrid fever. This practice was followed previous to the appearance of the *yellow fever* in America. Vide the Letters of Dr. THORNTON, &c. to Dr. BEDDOES.

" the ſituation of the other child was far different. " As he entered the houſe, the father informed him, " that his child was at the point of death, and all he " could hope from him now was, in ſome degree to " palliate her ſufferings. For three days and as many " nights every thing taken into her ſtomach had been " rejected. During this time ſhe had had no ſleep. " When Dr. THORNTON entered the room ſhe had " been juſt convulſed, was ſpeechleſs, and gaſping " for breath. Her eyes were fixed and ſunk, and " ſurrounded with a circle of a darkiſh colour. The " muſcles of the face ſtill quivered. He immediately " opened the window, for the room had but one, " and ordered the fire to be put out. The room was " then darkened, and filled with fine ſprays of *vinegar*, " which, by abſorbing the heat of the room, cooled " the chamber, and became aeriform, when, to the " great ſurpriſe and ſatisfaction of the perſons who " were preſent, ſhe revived, and her ſpeech, after a " few minutes, returned to her. As ſhe ſeemed exhauſted " for want of food, Dr. THORNTON ordered " her the white of an egg, which of all nutritious " ſubſtances he judged the leaſt ſubject to putrefac-

" tion, mixing it with white wine, warm water, " cinnamon, and *lemon juice*; he gave her very " ſmall quantities at a time, and finding it remained, " he ſoon after tried bark and red wine, which was " impregnated with FIXED AIR, directing the " ſame manner of adminiſtration, namely, to ſtop " whenever the ſmalleſt inclination to vomit- " ing came on. She had water impregnated with " FIXED AIR to drink, and was recovering faſt " under this treatment, when ſome officious ignorant " nurſe interfered, and the fire was renewed in the " apartment, and the child was loaded with flannels; " in conſequence of which ſhe was again ſeized with " ſimilar convulſions, and became ſpeechleſs: but " in leſs than five minutes ſhe was reſtored as before " by breathing a *ſuperoxygenated air*. In the courſe " of a few days, from the evacuant, antiſeptic, and " tonic treatment, ſhe was out of danger, and able " to leave her bed."

LXI. We ſhall not detain the reader with any fuller detail concerning putrid fever, as the ſubject will be again reſumed *, but ſhall haſten briefly to relate the new trials which have been lately made in *ſcurvy*. From the reſemblance of the blood taken from the arm with that of a perſon labouring under a putrid fever (for the blood does not, or very feebly coagulates), from the ſallowneſs of the countenance,—the black and blue ſpots ſuffuſed over the ſurface,—the coldneſs of the body,—&c. the illuſtrious Dr. BEDDOES firſt conjectured that in *ſcurvy* there was a deficiency of OXYGEN in the blood, and ſuggeſted a plan of treatment according to this theory †. Soon after, a practical treatiſe ‡ appeared, written by Dr. TROTTER. "It is our duty," ſays this learned and humane phyſician, "to draw philoſophy from the

Of ſcurvy.

Dr. Beddoes's hypotheſis

firſt realized by Dr. Trotter.

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* We ſhall then do juſtice to the *diſcovery* of Sir William FORDYCE, and relate the extraordinary recovery of the ſon of Lord BUTE, by means of the MURIATIC ACID, which from the hurry of writing was omitted; and we ſhall then likewiſe conſider the practice of Dr. JAMES, and enter fully into the merits of his juſtly celebrated powder.

† Vide *Obſervations on the Nature and Cure of Calculus, Sea Scurvy, Conſumption, Catarrh, and Fever*; by Thomas BEDDOES, M. D.

‡ *Medical and Chemical Eſſays: containing obſervations on ſcurvy; communications from South Wales; the caſe of a blue boy; and thoughts on the chemical nature and decompoſition of water, with a certain method of preſerving it pure and ſweet in long voyages.* By THOMAS TROTTER, M. D. Phyſician to his Majeſty's Fleet under the command of Admiral Richard Earl Howe.

" laboratory of the chemiſt, and make her ſubſervient " to the practical purpoſes of life. Whilſt I had the " advantage of collecting facts on the ſubject of " ſcurvy, Dr. BEDDOES had ſuperior advantages to " me, in improving and extending the doctrine " which I had adopted. A ſituation infinitely more " favourable to philoſophical retirement, a knowledge of chemiſtry inferior to none in our age, a " love for the ſtudy, and a deſire to reduce it in " practice, to the relief of his fellow-creatures, have " brought us to an æra in the hiſtory of medicine, " that has unfolded to our view, ſecrets of nature, " on which our predeceſſors in ſcience were not even " able to form a plauſible conjecture. In February " 1793, I was removed," ſays Dr. TROTTER, " from the Centurian to the Vengeance of 74 guns, " then at Spithead, and fitting to receive the broad " pendant of Commodore Charles Thomſon, now " Rear Admiral; and intended for the Leeward " Iſland ſtation. The work * of Dr. BEDDOES was " at this time put into my hands. The company of " the Vengeance had a quart of cocoa a man, with

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* *Obſervations on Calculus, Sea Scurvy,* &c. Vide note, page lxxxvii.

" ſugar enough to ſweeten it, for breakfaſt, in lieu " of oatmeal, butter, and cheeſe. They had for " dinner excellent ſalt meat. Yet ſcurvy was not " prevented from making its inroad. The officers of " this ſhip, who at firſt had always plentifully ſhared " their freſh ſtock with the ſick, could in the preſent " inſtance afford them no aſſiſtance, for they had " but a very ſmall ſtore on board, not ſufficient to " laſt them a third of the preſent voyage. Many " perſons were in conſequence violently afflicted with " ſea-ſcurvy.

" Robert Bell, aged thirty, was a ſeaman, and " impreſſed: his ſymptoms of ſcurvy were ſpungy " gums, hardened and contracted hams, livid ſpots " on the thighs and legs, very much depreſſed in " ſpirits, and apprehenſive. He was ordered vitrio- " lic acid diluted in water, in as great a quantity as " his ſtomach and bowels would bear without pain. " For the firſt two or three days Bell had better " ſpirits and looked more lively; but the benefit did " not continue, for he grew much worſe at the end of " a week. It was then changed for juice of LIMES, " which in a few days effectually cured him. The " effect of LIME JUICE, as I have had many occa- " ſions

Dr. Trotter's diſcovery.

" ſions ſince to obſerve, was apparent always in leſs " than twenty-four hours. Five caſes of nearly the " ſame deſcription followed the above; and the reſult " was uniformly the ſame. In the fond attachment " to the philoſophy of phyſic, and the enthuſiaſm of " ſcientific enquiry, one may be ſometimes betrayed " into fallacious concluſions. But diveſting myſelf of " all partiality for a favourite opinion, I can have no " doubt," continues Dr. TROTTER, "that the good " effects of the CITRIC ACID in the cure of *ſcurvy*, " are entirely owing to its imparting OXYGEN to " the blood, however difficult it is to reconcile it " with the want of efficacy in the other acid in curing " this diſeaſe."

" In December, 1793, I was appointed phy- " ſician to the royal hoſpital at Haſlar, Portſmouth. " This hoſpital is attended by two phyſicians. The " ſouth ſide fell to the lot of Dr. John LIND, and " the north to me. The firſt patient in ſcurvy, who " came under my care, was John Driver, belonging " to the Queen Charlotte, the flag ſhip of Earl " Howe. His ſymptoms were inveterate, and the " hams ſo contracted that he could not walk. He " was by the aſſiſtant diſpenſer put on the *vinum an-*

" *tiſcorbuticum* of the hoſpital, the ſame as preſcribed " by LIND ſenior. At the time I viſited him, he " had taken his medicine for two days, and was on a " diet of mutton and greens; yet he found himſelf " worſe. He was immediately ordered two ounces of " the CITRIC ACID three times a day. On calling to " ſee him next morning, I found him ſtill worſe, " and ordered him two ounces of the ſame acid four " times a day. On the day following, I was yet " more ſurpriſed, that his complaints were not beginning to yield. He was now yellow or livid all " over, and his pains at night tormenting. The " nurſe and other people in the ward aſſured me that " his medicine was faithfully taken. From this I " was led to examine the bottle at the head of his " bed, where, inſtead of *lime juice*, it was the *diluted ſulphuric acid.* There were, it appeared, " no lime juice in the diſpenſary, and the *ſuccedaneum* had nearly coſt the man his life. I now ſupplied him with ſixteen ounces of the CITRIC ACID, " concentrated by congelation. With this preparation he recovered in a few days; and was ſoon after " diſcharged to his ſhip."

Mr. Patterſon's diſcovery.

LXII. “ While a ſurgeon in the royal navy, I “ have, oftener than once, had occaſion,” ſays Mr. Patterson, “ to lament the limited power of me-“ dicine, and in no particular inſtance more than in “ ſcurvy. In various ſtations, and in oppoſite cli-“ mates, I have had frequent opportunity of ob-“ ſerving this diſeaſe, in all its variety; and, at “ times, obliged to witneſs it, in all its hideous “ ſhapes, without having it in my power to put a “ ſtop to its deſtructive career. Such ſcenes as theſe “ are well calculated to make a medical man atten-“ tive. I could not fail to obſerve the great deſire “ that ſcorbutic patients have for *acids*. People, la-“ bouring under this diſeaſe, have been known to “ uſe, in the way of drink, and in ſeaſoning their “ food, one pint of vinegar in the courſe of the day, “ and with impunity. One patient drank during “ a night a whole quart, without any painful or “ diſagreeable ſymptoms ſupervening. Having ſeen

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[*] Vide *A Treatiſe on the Scurvy: containing a new, eaſy, and effectual, method of curing that diſeaſe; the cauſe, and indications of cure, deduced from practice; and obſervations connected with the ſubject; with an Appendix conſiſting of five letters, reſpecting the ſucceſs of a new antiſcorbutic medicine.* By Mr. Patterson, Surgeon in the Royal Navy.

" the good effects of *nitre* (nitrous acid combined " with alkali) in ſeveral caſes of ſcurvy, and kowing, " from the diſcovery in chemiſtry, that it contained " a vaſt quantity of the *acidifying principle*, or VI- " TAL AIR, I was led to make a ſolution of this " ſalt in *vinegar*. Before I adminiſtered this new " remedy, I made the following experiments out of " the body. I took the blood from a patient in " ſcurvy, and from a man in health, and having cut " off the florid ſurface of the coagulum, I poured " ſome diluted *vitriolic acid* on the dark coloured " coagulum, and it aſſumed a *blacker* appearance in " both cups. On the contrary, when I poured this " ſolution of *nitre* in *vinegar*, the colour of the coa- " gulum was immediately changed to a beautiful *red*, " more bright than even arterial blood, it even turn- " ed to a bright *red* that dark coagulum which the " diluted vitriolic acid had nearly rendered black. " Upon the firſt favourable occaſion, I was reſolved " to try this ſolution, and I had ſoon occaſion to put " it to the teſt of experiment; and with inexpreſſible " pleaſure I found it, in a vaſt variety of caſes, ſuc- " ceed beyond my moſt ſanguine expectation. By " means of the *nitrous vinegar*, the belly, in general,

" is kept gently lax; the diſcharge of urine is in-
" creaſed, and changes from an alkaline to a healthy
" nature; the ſkin becomes open, and more agree-
" able to the touch; the chillineſs is changed to a
" pleaſing warmth; and the pulſe acquires ſteadineſs
" and healthy ſtrength. Sleep comes to be more
" natural. The ſallow and the gloomy countenance
" is gradually changed into the cheerful. The gums
" heal and grow firm. The lower extremities loſe
" faſter than could be ſuppoſed their livid hue; they
" gradually become ſofter, leſs painful, and more
" flexible; and ulcers put on an healthy appearance,
" and ſoon ſkin over. The great oppreſſion about
" the breaſt gives way; and the cough and breathing
" become leſs laborious. The appetite and the ſenſe
" of taſte is reſtored. The depreſſion of ſpirits and
" the laſſitude are forgot. The ſtrength increaſes;
" and, at laſt, health is re-eſtabliſhed. In the month
" of July 1794, I made comparative trials with this
" ſolution, and the juice of *limes*, and after having
" duly weighed all circumſtances, I am inclined to
" decide in favour of the former; one advantage,
" however, it certainly poſſeſſes over the latter, as it
" conſiſts of articles which may at all times, and

"with very little expence, be obtained, and without "difficulty preſerved; in ſhort, it is the *deſideratum* "which Dr. **Beddoes** has attempted to eſtabliſh."

LXIII. We are now arrived at the moſt brilliant æra in phyſic, The different factitious airs were ſoon after tried at the Hotel Dieu in Paris, many of which proved ſucceſsful, but ſome turning out inauſpicious *, and the revolution ſucceeding, with the tyranny of **Robiespierre**, who put to death **Lavoisier**, and many other literary characters, a veil was drawn over this new branch of ſcience for a time, but as **Fourcroy** juſtly obſerves, "the "analogy of action which has been diſcovered between digeſtion, reſpiration, circulation, and inſenſible perſpiration, has begun to eſtabliſh on "new views, more ſolid than were heretofore poſſeſſed, *a ſyſtem of* ANIMAL PHYSICS, which promiſe an abundant harveſt of diſcoveries and improvements. Unqueſtionably it will be, in purſuing the chemical changes that are undergone in "the ſyſtem, that an EDIFICE equally *novel* and *ſolid*

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[*] The trial of vital air in conſumption. For a remark on this, conſult Vol. III. p. 655, note †.

"will be erected. Every thing is ready for this "ground-work; ſeveral philoſophers purſue this un-"beaten path of experience; freſh ardour, ſpringing "from theſe new conceptions, animates thoſe who "are engaged in this branch of phyſics; and the "track they have juſt begun to explore appears ſuch "as muſt lead them to more precious and accurate "reſults, than any that have hitherto been advanced "on the functions which conſtitute animal life."

Dr. Beddoes.

LXIV. Whilſt the progreſs of the pneumatic practice of phyſic was ſtopped in France by the revolution, Dr. BEDDOES, the celebrated profeſſor of chemiſtry at Oxford, endeavoured to turn the attention of the faculty in *England* to this new branch of ſcience. His works ſoon paſſed into the hands of every one: for he poſſeſſed the rare art of diffuſing through his writings that lively intereſt, that enchanting colouring, and that delicate and vigorous touch, which influence, attach, and ſubdue the mind. The profundity of his reaſoning is every where united to all that agreeable imagery, which the moſt brilliant imagination can furniſh. The ſacred fire of genius animates all his productions; his theories conſtantly exhibit the moſt ſublime proſpects in their totality, and the moſt perfect correſpondence in their parts; and even whilſt he raiſes *hypotheſes*, we are inclined to perſuade ourſelves that they are eſtabliſhed truths.

The higheſt commendation is certainly due to this ingenious philoſopher for his chemical inveſtigation of diſeaſes. The novelty of the attempt ſoon expoſed him to the malignity of ſome not equally well diſpoſed, and the ardour of purſuit was branded with the name of enthuſiaſm; but a virtuous mind, intent on a generous action, looks upon theſe as ſo many ſteps to diſtinction; for to be either very good or very great, is to be very much envied, and very much miſrepreſented. Even ſome who differed with this gentleman in political ſentiments ſided with the envious and intereſted againſt the *pneumatic remedies:* as monks formerly denied the Newtonian philoſophy, only becauſe NEWTON was a proteſtant. It is a great misfortune, ſays Dr. PRIESTLEY, "when "philoſophers forſake their purſuits of nature, which "are ever regular and uniform, to engage in the "confuſion of political conteſts."—And who is there but muſt regret the flight from this country of the author of this very remark, which ſome years ago he made to the illuſtrious FRANKLIN? And philoſophy droops her head; ſince LAVOISIER was guillotined........He requeſted but three days to finiſh an important experiment he had begun, and the ſtern tyrant[*] replied, "France has no need of "philoſophers; but of patriots;" and ordered him inſtantly to execution.—But Dr. BEDDOES may perhaps reply, "Homo ſum, et humani nihil a me "alienum puto,"—to which I confeſs I ſhould be at a loſs what to anſwer!—His theories of diſeaſes[†] will no doubt one day or other conſpire, with future diſcoveries in chemiſtry, to unravel the whole of their myſterious operations: and ingenious phyſicians, having learnt to manage their intricate and multifarious machinery, may ſee that art, which can reſt firmly upon no other foundation than a juſt theory of the functions of the body, riſing under their hands into a *beautiful* and *ſolid* STRUCTURE. Nor, however remote medicine may at preſent be from ſuch perfection, do I ſee any reaſon to doubt that, by taking advantage of various and continual acceſſions as they accrue to ſcience, the ſame power will be acquired over living, as it is at preſent exerciſed over inanimate bodies; and that not only the cure and prevention of diſeaſes, but the art of protracting the faireſt ſeaſon of life, and rendering health more vigorous, will one day half realize the dream of alchemy.

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[*] ROBIESPIERRE.

[†] Vide *Obſervations on the Nature and Cure of Calculus, Sea Scurvy, Putrid Fever*, &c.

Dr. Darwin.

The celebrated Dr. DARWIN, who has of late turned his attention much to this ſubject, obſerves, "that VITAL AIR penetrates the fine moiſt membranes of the air-veſſels of the lungs, and unites "with the blood by chemical attraction, as is ſeen to "happen, when blood is drawn into a baſon, for "the lower ſurface of the craſſimentum is of a dark "red ſo long as it is covered from the air by the "upper ſurface, but becomes florid in a ſhort time "on its being expoſed to the atmoſphere. The perpetual neceſſity of the mixture of VITAL AIR "with the blood in the lungs, evinces that it muſt "act as a ſtimulus to the ſanguiferous ſyſtem, as the "motions of the heart and arteries preſently ceaſe, "where animals are immerſed in air which poſſeſs "no oxygen."—It may alſo ſubſequently anſwer another important purpoſe, as it probably affords the *material* for the production of the SENSORIAL POWER *; which is ſuppoſed to be ſecreted in the brain and medullary part of the nerves; and that the perpetual demand of this fluid in reſpiration is occaſioned by the SENSORIAL POWER, which is ſuppoſed to be produced from it, being too ſubtle to be confined in any part of the ſyſtem †.

Mr. Townſend.

The Rev. Mr. TOWNSEND, the learned author of *the Guide to Health*, obſerves, when ſpeaking of the different FACTITIOUS AIRS, "that theſe promiſe, under the ſkilful management of Dr. BEDDOES at the Hot Wells, Briſtol, and Dr. THORNTON in London, to be a remedy well worthy the attention of the medical practitioner. The VITAL AIR, properly diluted with common air, is a ſtimulus the moſt natural and diffuſive. It promotes the inſenſible perſpiration, greatly aids digeſtion, favours ſleep, exhilarates the ſpirits, and relieves difficult reſpiration. It is found of the higheſt advantage in moſt nervous diſeaſes. The AZOTIC AIR abates inflammation, and is

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* For an explanation of this term, vide Vol. III. page 461.

† Vide *Zoonomia, or the Laws of Organic Life*, Vol. II. A work which occupied, as this philoſopher ſays, thirty years deep meditation.

“the only remedy with the HYDROGEN AIR, that is found capable of arreſting the progreſs of conſumption, and the CARBONIC ACID AIR is a moſt powerful antiſeptic.”

The effects of the vital air when given in a properly diluted form as a remedy.

It being aſcertained by direct experiment, that the heart and arteries can be *raiſed*[*] from 64 to 120 pulſations in a minute, by the inhalation of pure OXYGEN, or VITAL, AIR, and that by abſtracting this VITAL GAS from atmoſpheric air, their actions can be *leſſened*[†] from 120 to 64 beats in a minute, the PNEUMATO-CHEMICAL *phyſician* has therefore a complete power over the heart and arteries, juſt as a

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[*] Although Mr. TAYLOR was not more than 22 years of age, his natural pulſe was only 64 previous to the experiment. During the inhalation of the pure OXYGEN AIR, his pulſe, as Dr. HIGGINS remarked, was quickened to 90 beats in a minute, and was conſiderably increaſed in *fulneſs* and *ſtrength*. The veſſel being immediately charged again with 19 pints of OXYGEN GAS, he reſpired theſe alſo, and conſumed them entirely in ſix minutes. His pulſe was in conſequence increaſed to 120 beats in a minute, and was *vigorous withal*. See *Minutes of the Society for Philoſophical Experiments*, p. 146. Alſo Dr. GOODWIN's Experiment, p. 79, and note *, p. 110.

[†] One conſumptive patient, contrary to my judgment, ſays Dr. BEDDOES, uſed to inhale at times air wholly deprived of *oxygen*. During this proceſs I have felt the pulſe nearly *obliterated*. He loved to indulge in it, and deſcribes the incipient inſenſibility produced on him as a ſtate highly delightful. Vide Dr. BEDDOES's *Obſervations*, p. 30.

watch-maker has a power over the movement of a watch by means of the regulator.

It being likewiſe proved, that the blood and ſolids are compoſed in part of VITAL AIR, he has alſo the power of altering the *maſs of blood*[*], and therefore of changing the conſtitution. He poſſeſſes in the VITAL AIR a means of unlocking *obſtructed veſſels*[†], promoting the *inſenſible perſpiration*[‡], quickening the *digeſtion*[‖], increaſing the *animal heat*[§] and *muſcular powers*[**], and of raiſing the *ſpirits*[††]. He can render the *reſpiration eaſy*[‡‡], and give *bloom*[‖‖] to the complexion.

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[*] Vide the celebrated Experiment of Dr. BEDDOES, which at the riſk of life he generouſly undertook in the cauſe of humanity, and for the improvement of ſcience. Vide Vol. II. p. 254.

[†] Vide Dr. BEDDOES's *Obſervations on the Medicinal Uſe of different Airs*, p. 44.

[‡] Vide the *Phyſician's Vade Mecum*, by the Rev. J. TOWNSEND, p. 113.

[‖] Vide Vol. I. Sect. VII. *On the Balance betwixt Digeſtion and the Oxygenation of the Blood*, p. 88.

[§] Vide Vol. I. Sect. VIII. *On Animal Heat*, p. 81.

[**] Vide Vol. I. Sect. XI. *On the Cauſe of Voluntary Action*, p. 125.

[††] Vide Vol. III. Sect. XXXIV. *On Oxygen as related to Senſibility.*

[‡‡] Vide Vol. I. page 89, line 15. Alſo note *, p. 126.

[‖‖] See *Minutes of Philoſophic Experiments*, p. 169. Alſo Vol. II. p. 257.

The VITAL AIR in the form of *acid fumes* has been adminiſtered, as was before obſerved, in PUTRID FEVER by Dr. Carmichael Smith. It has been alſo ſucceſsfully inhaled, when diluted with atmoſpheric air, in the ſame dreadful calamity, under Dr. Thornton. It has been in this way adminiſtered in HYDROCEPHALUS, HYDROTHORAX, and in ACITES, under Drs. Beddoes, Darwin, and Thornton:—in ASTHMA and DYSPNŒA by Drs. Beddoes, Thornton, Ferriar, and Carmichael; in CHLOROSIS by Drs. Thornton, Carmichael, Pearson, and Alderson; in HEAD-ACH by Drs. Darwin and Thornton; in HYSTERIA by Dr. Thornton; in DYSPEPSIA by Dr. Thornton; in HYPOCHONDRIASIS and MADNESS by Dr. Thornton; in ULCERS OF THE LEG by Dr. Thornton and Mr. Hill; in SCURVY and SYPHILITIC DISEASES by Dr. Thornton and Mr. Hill; and laſtly, in PALSY, EPILEPSY, and AMAUROSIS, by Drs. Beddoes, Thornton, and Pearson *.

The diſeaſes in which the vital air has been ſucceſsfully employed.
Putrid fever.
Dropſy of the brain, of the cheſt, and of the abdomen.
Aſthma and difficult reſpiration.
Green ſickneſs.
Head-ach.
Hyſteric fits.
Want of appetite.
Dejection of ſpirits.
Melancholy madneſs.
Ulcers.
Syphilis.
Palſy.
Epilepſy.
Loſs of Sight.

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* Vide Dr. Beddoes's *Conſiderations of the Medicinal Uſe of Factitious Airs*, the Rev. Mr. Townsend's *Guide to Health*, and Dr. Darwin's *Zoonomia*; where the reader will find theſe trials recorded.

Attention is undoubtedly not leſs due to the OTHER ELEMENTS of *organized bodies* ; and if the importance of OXYGEN ſeems to have been chiefly inſiſted on in the foregoing obſervations, it is only becauſe we have very few facts which afford a foundation for reaſoning concerning the connection of an exceſs or deficiency of CARBON, HYDROGEN, or AZOT, with the functions of life: and yet much obſcurity and many difficulties muſt be expected to remain, till we acquire the knowledge of ſuch facts. Let us however ſet a due value on our preſent knowledge, though it be imperfect ; and reſtrain thoſe rude hands that are ever ready to pluck up the tender plants of ſcience, becauſe they do not bear *ripe fruit* at a ſeaſon when they can only be putting forth their bloſſoms.

The diſeaſes in which the mephitic airs have been ſucceſsfully employed.

Conſumption.

Cancer.

The CARBONIC ACID AIR, or *fixed air*, has however been applied in PHTHISIS by Drs. PERCIVAL, WITHERING, BEDDOES, and EWART. It has been alſo employed by the latter phyſicians in CANCER, whoſe fœtor it corrects, and whoſe torture it alleviates. The HYDROCARBONATE (which appears to be a mixture of *fixed*, and *inflam-*

mable, airs) has been applied in PHTHISIS by Drs. BEDDOES, ALDERSON, CARMICHAEL, FERRIAR, and THORNTON; in HÆMOPTOE by Drs. REDFEARN and THORNTON; and the HYDROGEN AIR (or *inflammable air*) has been applied in PHTHISIS by Drs. BEDDOES and THORNTON; in CATARRH by Drs. THORNTON, BEDDOES, and Mr. BARR; in CROUP by Dr. THORNTON; and in PLEURISY by Drs. BEDDOES, THORNTON, FERRIAR, and MACDONALD.

Conſumption.

Spitting of blood.

Catarrh.

Croup.

Pleuriſy.

To conclude.—The pneumatic doctrine of phyſic has met with a welcome reception, not only among the learned of our own country, but in foreign parts. Dr. RUSH has endeavoured to apply it to the explanation of ſome appearances exhibited in the late deſtructive fever at Philadelphia. In other parts of *America* phyſicians of the greateſt celebrity have ſpoken in favourable terms of this inveſtigation. Dr. GARNET has gone out from this country, with an appointment of three hundred a year, to *North America*, as a profeſſor of experimental and natural philoſophy, and is deeply engaged in unfolding the nature of eruptive diſeaſes upon the new doctrines. In *India* this inveſtigation has proceeded with rapidity, and has been ably applied by Dr. BRIGGS in illuſtrating the cauſe of hepatic affections. At *Vienna*, where the ſubject was early introduced by a letter from Dr. INGENHOUZ to Dr. SCHERER, it has been warmly taken up. Above three hundred trials with the VITAL AIR have already been made there, and a premium for determining the medicinal effects of elaſtic fluids has been offered by one or more German academies. *Spain*, which can boaſt of medical men of the moſt enlarged views, has adopted meaſures ſtill more deciſive. The Engliſh tracts, in which the uſe of airs in medicine is recommended, have, I am informed, been tranſlated by order of government; and what is more to the purpoſe, I certainly know that a ſmall *pneumatic hoſpital* has been eſtabliſhed at Madrid. In *Pruſſia* it has been purſued by Dr. ACARD. In *France*, when that infatuated people ſhall have conquered leiſure, it will be revived. In ſhort, the ANTI-PNEUMATISTS, if I may ſo denominate thoſe who are eager to ſtifle the enquiry, whatever be their *local vogue*, will principally be found among phyſicians, neither *liberal* in *their conceptions*, nor *converſant in that great branch of natural philoſophy, which unfolds the properties of* PERMANENTLY ELASTIC FLUIDS.

Mr. CLINE, the juſtly admired lecturer on anatomy at St. Thomas's Hoſpital, inſtead of an introductory lecture, immediately enters upon his courſe, and defers this general account of the progreſs of the ſcience, as a ſummary, at the concluſion, when it can, as he ſays, be better underſtood: but we have here followed the plan of the late Dr. HUNTER, father of a no leſs illuſtrious ſchool, thinking that this preface may be read with *ſome* advantage at the commencement; it muſt inſpire ardour, and command attention, in the reader, and may be *re-peruſed* at any ſubſequent time, ſhould the indulgent reader confer on it that honour.

CVII

kind among physicians, [illegible]

[illegible]

PART I.

A SUMMARY

OF THE

PNEUMATIC CHEMISTRY.

OTHER ages may have ſurpaſſed the preſent in the greatneſs of ſome ſingle event, ſuch as the rapid conqueſt of half the globe by an ALEXANDER or a TAMERLANE. Nevertheleſs, the age in which we live, ſeems to me, of all the periods in hiſtory, the moſt diſtinguiſhed for the ſudden and extenſive impulſe which the human mind has received, and which has extended its active influence to every object of human purſuit. The diffuſion of a general knowledge, and of a taſte for ſcience, over all claſſes of men, in every nation of Europe, or of European origin, ſeems to be the characteriſtic feature of the *preſent age.* The ſtudy of the ſciences principally has expanded the mind, and laid it open for the reception of every kind of truth. Some individuals of rare genius in former times may perhaps ſeem to excel thoſe of the preſent day; although in juſtice to theſe, it ſhould be remembered that luminous bodies ſhine brighteſt in obſcurity. But in no former age, was ever the light of knowledge *ſo extended*, and ſo *generally diffuſed.* Knowledge is not now confined to public ſchools, or to particular claſſes of men. It is not at this day, that ſome celebrated and immenſely learned profeſſor delivers from his academic chair dictates to his auditors, who preſs from all quarters to catch the oracular ſounds, and afterwards to revibrate his ipſe dixits. In *this age*, the flame that paſſes over all, kindles the ſparks of genius wherever they may happen to lurk, and every man forms an opinion for himſelf.

KEIR.

INTRODUCTION.

OF THE ATTRACTION WHICH TAKES PLACE BETWEEN BODIES OF THE SAME KIND, OR THE ATTRACTION OF COHESION.

PREVIOUS to our explaining the laws of *chemical attraction*, we ſhould firſt briefly contemplate the *attraction of gravitation*, or that power which draws bodies to the center of the earth. It is from this law that different bodies in the creation aſſume their proper ſtation, heavy bodies deſcend, and light ones aſcend; by this, projectiles are directed, vapours and exhalations riſe, and rains fall; by this, rivers glide, the air preſſes, and oceans ſwell. If we extend our mind, we ſhall perceive that this law alſo governs all the planetary worlds. Projected by the almighty FIAT, they would roll on through the infinitude of ſpace in ſtraight lines, but the central ſuns overcoming in part this power by *the law of* *of gravity*, hence each planet forms his own reſpective circle: but *chemical attraction*, or the *attraction of cohesion*, we are about to conſider, is that principle which joins and combines into little ſyſtems thoſe ſeveral and diſtinct corpuſcules which form different ſubſtances. It is that *attractive force* by which they tend mutually towards each other; which force only exiſts in the very point of cloſe contact, at little diſtances is leſs, and at a little further diſtance is quite inſenſible.

The *attraction of gravitation* acts only upon large bodies, and is always in proportion to their maſſes; whereas *chemical attraction* affects only minute bodies, and has abſolutely no influence upon ſuch as are of any conſiderable bulk. *Gravitation* acts upon bodies placed at immenſe diſtances from each other; whereas *chemical attraction* never acts but with bodies in mutual contact.

We ſee then that theſe two attractive powers are different, and they are not natural to inert bodies, but a property implanted by the CREATOR no leſs confounding to the philoſopher than that amazing property in animal bodies, which we denominate the life or ſoul.

This property of dead matter is of three kinds.

The firſt is where the integrant parts are united by a very conſiderable force, and forms the *hard* or *ſolid aggregate*. Thus two ſmooth plates of any metal placed in contact, will ſo firmly adhere as to ſupport many hundred pound. Thus the particles of a diamond are ſo cloſely united, as to make one of the hardeſt ſubſtances in nature. This genus comprehends many ſpecies from the hardneſs of rock-cryſtal to the yielding contexture of the ſofteſt wood.

The ſecond is called the *pliant*, or *ſoft*, or *fluid aggregate*, where the parts may be eaſily moved backwards and forwards ſo as to change their relative ſituation: as wax, putty, and water.

And third, the *aeriform*, or *gaſeous*, *aggregate*, the tenuity of whoſe integrant particles renders them imperceptible, and in which the attraction of coheſion is the leaſt poſſible.

Theſe *three ſtates* are however, properly ſpeaking, but *one* and the *ſame power*, and moſt probably owe their diſtinctive difference to *caloric* or *matter of heat*, which pervades all bodies. The better to determine our ideas relating to this ſubject, which has not hitherto been ſufficiently conſidered, let us, for a moment, conceive what would take place in the various ſubſtances which compoſe our earth, if its *temperature* were ſuddenly altered. If, for inſtance, we were tranſported into the region of the planet MERCURY, where probably the common temperature is much ſuperior to that of boiling water. The rivers of the earth, and all the other fluids which are ſuſceptible of the gaſſeous ſtate, at the temperature near to that of boiling water, would become rarefied; and all theſe ſubſtances would be changed into permanent aeriform fluids or gaſſes, which would become part of the new atmoſphere.

By a contrary ſuppoſition to the one we have been forming, if the earth was ſuddenly tranſported to where the GEORGIUM SIDUS is, or ſome planet equally cold, the water which compoſe our ſeas, rivers, and ſprings, and probably the greater number of the fluids we are acquainted with, would be converted into ſolid mountains and hard rocks, at firſt tranſparent and homogeneous, like rock cryſtal, but which, in time, being mixed with different coloured earths, would form opake ſtones of various colours. In this caſe the air would loſe its elaſticity for want of a ſufficient temperature to retain it in that ſtate: it would return to the liquid ſtate of exiſtence,

iſtence, and new liquids would be formed, of whoſe properties at this moment we have not the moſt diſtant idea.

Although theſe two hypotheſes may give a tolerable diſtinct idea of our poſition, that *ſolid*, *liquid*, and *aeriform aggregates* are only three different ſtates of exiſtence of the ſame matter, or three particular modifications, which almoſt all ſubſtances are ſuſceptible of aſſuming ſucceſſively, and which ſolely depend upon the degree of *temperature* to which they are expoſed; or upon the degree of *caloric* with which they are penetrated; yet as this opinion is the baſis of all chemical ſcience, I ſhall enter a little further into the conſideration of this very important ſubject.

GENERAL LAW RESPECTING HEAT.

I. ALL BODIES ARE EXPANDED BY HEAT.

1ſt. State of Expanſion.

As compariſons with ſenſible objects are of great uſe in aſſiſting us to form diſtinct notions of abſtract ideas, we ſhall endeavour to illuſtrate this poſition, by inſtancing the phænomena which takes place between water and bodies which are penetrated by it. If we put a loaf of bread into water, this fluid will gradually inſinuate itſelf into its pores, and the bread is ſoon conſiderably augmented both in weight and magnitude.—Or if we put a piece of wood into water, it will ſwell by admitting the water into its ſubſtance.—Or if a dry ſponge be dipped in water, the ſponge ſwells, its particles are ſeparated from each other, and all its intervals are filled up by the water. The ſame circumſtance undoubtedly takes place with regard to bodies which are immerſed in free CALORIC *. Thus if you take an iron tube, which is filled up exactly by a rod, and heat this rod, it will be found too large for the tube, and will not enter it: and if you put it by the ſide of the tube, you will find it alſo longer than the tube, which when cold it appeared ſo exactly to fit. Its dimenſions are therefore *increaſed* both in diameter and length. It is ſo with rings on the finger. The ring which in health appeared exactly to fit, will drop off in the cold fit of an ague, and will be found on the contrary immoveable during the hot fit. It is upon this principle, that veſſels and the wheels of carriages are bound with hoops heated red hot, and applied in this their expanded ſtate, after which they pour cold water upon them, when the iron contracts with ſuch force as to make a deep impreſſion on the wood, and in this way the veſſels are bound much faſter than they would be by any other means. It is alſo upon this principle that our *thermometers* are conſtructed.

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* Diſtinguiſhed thus from latent or combined heat.

The Thermometer.

The firſt invention of this curious and uſeful inſtrument is ſomewhat obſcure: but previous to the time of Sanctorius it does not appear that the expanſive power of heat was much obſerved. Sanctorius's thermometer was a hollow glaſs ball, with a long cylindrical tube attached to it, with a ſmall opening at the top, and therefore containing a quantity of air, and in order to obſerve the variation of the bulk, or elaſticity which the air in the ball and tube underwent from the application of heat, he firſt expelled a ſmall quantity of air out of the veſſel by applying heat to it. In conſequence of which the air expands, and a ſmall quantity of it comes out. He then puts the extremity of the tube immediately into a coloured liquor, and allows the veſſel to become cool again; the conſequence is, that the air loſes the increaſe of its elaſticity, and the internal air preſſes up* a quantity of the fluid into the tube to fill up the room of the air that had been expelled by the heat, and having thus ſet up his thermometer, he then applied to the tube a ſcale of equal parts or degrees, which divides the cavity of the tube into a number of ſmall and equal parts; and as the tube is cylindrical, we can ſee by theſe diviſions, how the bulk of the air is increaſed at one time, and diminiſhed at another. This kind of thermometer was uſed for a conſiderable time, when at laſt it was objected to by the Honourable Mr. BOYLE, that it could not be employed to aſcertain the temperature of fluids, and owing to the changes which are known to take place in the weight of the atmoſphere, it was fallacious even in thoſe caſes in which it could be employed; he therefore attempted to conſtruct a thermometer on ſome other ſubſtance than air, and *ſpirit of wine* was firſt thought on, upon account of its being eaſily tinged, and the conſiderable change of bulk that it undergoes; and it was very eaſy to contrive the manner of confining the ſpirit of wine, or any other fluid, ſo as to obſerve diſtinctly the ſmalleſt variation of its bulk by putting it into a ball and tube, whereby a quantity riſes in a ſmall and ſlender thread, which can be eaſily meaſured, and divided into a number of ſmall parts, the extremity of the tube being ſealed hermetically, ſo that the preſſure of the atmoſphere could not effect it, nor could it ſuffer any loſs from exhalation; thus the firſt uſeful thermometer was contrived by the Honourable Mr. BOYLE. Theſe thermometers were uſed for twenty or thirty years, till Dr. HALLY and Sir Iſaac NEWTON preferred *mercury*.

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* Vide Vol I.

The pulſe glaſs.

The *pulſe glaſs*, as it is improperly called, depends alſo upon this principle. It is a bulb with a long neck to it. As the heat of the hand, following its natural tendency, immediately paſſes into the colder ſpirit of wine, in proportion as it enters it increaſes its bulk, and makes it gradually riſe higher into the neck of the veſſel, till it has acquired its utmoſt limit, when it appears to bubble; and to ſhew that it depends upon heat merely, it will do the ſame if immerſed in hot water; and then if it be removed it will again diminiſh in bulk, and return to its former place.

Before I quit the ſubject of *expanſion*, it may not be improper to notice, that a knowledge of this law enables us to underſtand the effect produced upon bodies that are remarkably brittle. Chemiſts know this but too well, and in private families glaſſes are repeatedly broken by pouring into them warm water, and even the backs of grates are ſoon cracked if cold water be thrown upon them after they are quickly heated. In theſe caſes the particles are torn from the colder parts by the expanſive power of heat.

2*d*. *State of Expanſion, or that of Fluidity.*

The firſt expanſion carried a little further produces the ſtate of *fluidity*. That this depends upon *abſorbed heat* merely, is proved by the following experiment. If you take a quantity of ice, and put it into a baſon, and carry it to a room in which the thermometer is at 50 degrees, from the increaſed temperature owing to a fire in the chamber, and leave this ice for ſome time in the room, part of it will be melted. Apply then a thermometer, and it will point to 32 degrees. The ſame in five minutes, though evidently more heat has entered the mixture, and ſo continually until every particle of ice, or ſnow, has been melted. This can only be accounted for by ſuppoſing that the free caloric, or heat, has entered into combination with the water, and remains, as chemiſts are wont to call it, in a *latent* ſtate. That is, the capacity of water for heat is greater than that of ice.

We may readily form an idea of the word *capacity*, by ſuppoſing a veſſel filled with marbles, into which a quantity of fine ſand is poured, which, inſinuating into the intervals between the balls, will fill up every void. The marbles, in this compariſon, are to the ſand which ſurrounds them exactly in the ſame ſituation as the particles of bodies are with reſpect to the caloric, with this difference only, that the marbles are ſuppoſed to touch each other, whereas the particles of bodies are not in contact, being retained at a ſmall diſtance from each other by the intervention of the caloric. If, inſtead of ſpherical balls, we ſubſtitute ſolid bodies of a hexahedral, octohedral, or any other regular figure, the capacity of the intervals between them will be leſſened, and conſequently will no longer contain the ſame quantity of ſand. The ſame thing takes place with regard to natural bodies, the intervals left between their particles are not of equal capacity, but vary in conſequence of the different figures and magnitude of their particles, and of the different figures and magnitude of their particles are maintained, according to the exiſting proportion between their inherent attraction, and the repulſive force exerted upon them by the caloric. In this manner we muſt underſtand the following expreſſion, introduced by the Engliſh philoſophers, who have given the firſt preciſe ideas upon this ſubject, the capacity of bodies for containing the matter of heat.

Of frigorific mixtures.

It is upon this principle alſo that *frigorific mixtures* are formed. The city of *Peterſburgh*, which is contiguous to the ſea, is expoſed to a very intenſe degree of cold, and that of the year 1760 being very exceſſive, the mercury ſtood even at 40 degrees below that of Farhenheit's ſcale. This being the caſe, Profeſſor Brown, of the academy there, had the curioſity to try whether by mixing together ice and ſtrong nitrous acid he could congeal even mercury itſelf; and the artificial cold this produced was ſo great, that he actually accompliſhed his experiment, and the mercury in the bulb was converted into a tough metal, which bore a ſtroke or two of the hammer; and what was in the bore turned out a very fine and flexible thread. Thus if a mixture of ſal ammoniac and ſnow be put over a fire, and we place in the middle of this a bowl with ſome water in it, whilſt the ſnow and ſal ammoniac is melting into a liquid, the water in the bowl will be congealed into a maſs of ice. We can have no doubt here, but that heat enters into bodies as they become *fluid*, ſeeing it torn in ſo ſurpriſing a manner from water during the melting of the ſnow. We ſee then, that as the change of the ice from the *ſolid* to the *fluid form*, it *abſorbed* a quantity of HEAT, even ſo much as to render mercury ſimilar in its properties to all the other metallic bodies.

3*d.* *State of Expanſion, or the Aeriform State.*

If you put a cup of æther in a baſon of water, and place them in the exhauſted receiver of an air-pump, the æther will aſſume an aeriform ſtate, and the water in the baſon will be frozen. In this experiment we ſee, that in the ordinary temperature of the earth, æther would always exiſt in an aeriform ſtate, but for the preſſure of the atmoſphere, and that the paſſing of the æther from the liquid to the aeriform ſtate is accompanied with a conſiderable diminution of heat; becauſe during the evaporation a part of the caloric, which was before either free or latent in the ſurrounding bodies, combines with the æther, cauſing it to aſſume the aeriform ſtate.

The effect of the preſſure of the atmoſphere in the converſion of bodies into theſe different ſtates was firſt noticed by the honourable Mr. **Boyle.** He found, when making experiments with the air-pump, that water boiled at 90 degrees when the preſſure of the atmoſphere was taken off, and that therefore both the freezing and boiling points upon thermometers were in ſome meaſure defective, being dependant upon the height of the barometer *; for when the preſſure was greateſt the water bore more heat, and vice verſa.

Papin's digeſter.

In conſequence of this diſcovery Papin formed his *digeſter.* In this inſtrument bones may be diſſolved, and the water may be made to acquire ſo great a degree of heat, that an iron wire will melt in it. For a deſcription of this inſtrument ſee Vol. II. page 229.

Before we quit this ſubject, let us for a moment conſider the cauſe of the *elaſticity* of *air*. It is by no means difficult to perceive that this elaſticity depends upon that of *caloric*, which ſeems to be the moſt eminently elaſtic body in nature. Nothing is more readily conceived, than that one body ſhould become elaſtic by entering into combination with another body poſſeſſed of that quality. Elaſticity is nothing more than that quality of the particles of bodies by which they recede from each other when forced together. We ſhall be ſatisfied of this, when we conſider that air is ſuſceptible of undergoing great compreſſion, which ſuppoſes that its particles were previouſly very diſtant from each other; for the power of approaching together certainly ſuppoſes a previous diſtance, at leaſt equal to the degree of approach.

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* Vide Vol. I. page 3.

Glaſs booms. The acquiſition of this property exhibits ſome of the moſt curious phænomena we are acquainted with. As children we have been often delighted with *candle-crackers*, but we ſhould now contemplate them as men. They are hollow pieces of glaſs formed upon the extremity of a tube. This tube is made to contain a drop or two of water, and it is then hermetically ſealed. When this is put near the flame of a candle, the water ſoon acquires the form of ſteam, the elaſticity of which is gradually increaſed, until it burſts the glaſs with an exceeding loud crack, and with ſuch violence, that uſually the wick of the candle is beat down upon the tallow as if it had received the blow of a hammer.

Alembics. The diſtillation of ſubſtances depends wholly upon this principle. Steam or vapour is produced by the elaſtic power of heat. This we have before ſhewn to vary with the preſſure of the atmoſphere. Accordingly it is found, that when the air is light (indicated by the barometer being low) the fluid will boil ſooner. When the barometer ſtands at 30 inches, water boils at the temperature of 212 degrees. If it ſtand ſo low as 28 inches, water will boil at 208. Hence in diſtillation we ſhould diminiſh the preſſure of the atmoſphere. It is undoubtedly of great advantage to be able by the ſecluſion of air to work with ſmaller fires, and this would ſecure us alſo in a great meaſure from thoſe fatal accidents which are often attended with the moſt terrible effects. Monſ. LAVOISIER was employed with his chemical friends on this important ſubject, when the Goth * of the eighteenth century, and his colleagues in iniquity, deprived the world of this great philoſopher. The flimſy pretext was that he occupied the place of farmer-general, a receiver of taxes under the former government, but the real motive which produced this execrable action was the juſtly acquired riches which he was known to poſſeſs. Thus was cut off the NEWTON of the preſent age in the midſt of his uſeful labours; his houſe, filled with the moſt expenſive chemical apparatuſes, free for his numerous viſitants, was deſpoiled; and the honourable rendezvous of men of letters was converted into a den of political thieves. The ſubject we hope, however, will not be dropt. The laws which regulate the formation of elaſtic vapour, and the phænomena they exhibit, give us that link which cloſely connects chemiſtry with mechanical philoſophy. Here we ſee chemical agents and mechanical forces ſet in immediate oppoſition to each other, and the one made the indication and meaſure of the other.

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* ROBESPIERRE.

Steam engine.

The *ſteam engine*, is the name of a machine which derives its moving power from the elaſticity of the ſteam of boiling water. It is the moſt valuable preſent which the arts of life have ever received from the philoſopher. The mariner's compaſs, the teleſcope, and other moſt uſeful diſcoveries, were the reſult of chance, and we do not know to whom we are indebted for them; but the ſteam-engine was, in the very beginning, the reſult of reflection, and the production of a very ingenious mind; and every improvement it has received, and every alteration in its conſtruction and principles, were alſo the reſults of philoſophical ſtudy. This invention was made in the reign of Charles II. by the Marquis of WORCESTER, which he publiſhed with ninety-nine other contrivances of his own, which he extols, as of the higheſt importance to the public. It does not, however, appear that the noble inventor could ever intereſt the public by theſe accounts. He was branded as a projector, and the many failures which perſons of this turn of mind daily experience, probably prejudiced people againſt him, and prevented all attention to his projects. The ſcheme however was revived in the year 1696 by Captain SAVARY, but it owes its preſent improved ſtate to the philanthropic Mr. WATT, a perſon of a truly philoſophical mind, eminently converſant in all branches of natural knowledge, and the pupil and intimate friend of Dr. BLACK, whoſe illuſtrious name will be often mentioned in this work, having of late turned his attention much towards the improvement of medicine by the formation and introduction of new aerial remedies *.

Without entering more diffuſely into examples of the conſequences of the change of capacity in bodies when they are altered in their form, it may be obſerved, and repeated once more, that as the powers of

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* Vide p. 608. note *.

gravity and *projection*, in continual oppoſition to each other, produce all the beautiful effects in the great ſyſtem of the univerſe; ſo, among the actions of the minute parts of bodies, the *coheſive attraction*, and the *repulſion* of *heat*, are in continual oppoſition to each other, and are concerned in almoſt every proceſs by which changes are produced in the peculiar properties, or chemical combination, of bodies.

To conclude. Beſides the extenſive influence of *heat*, chemiſts, in order to deſtroy as much as poſſible THE ATTRACTION OF COHESION, employ the mechanical operations of *pounding*, *hammering*, *raſping*, *filing*, or *cutting*, and not unfrequently the operation of *ſolvents*. Hence that adage, "Corpora non agunt niſi ſint ſoluta;" by which means they give free ſcope for THE ATTRACTION OF COMPOSITION, or AFFINITY, or that attraction which takes place between bodies of different natures.

SECT. I.

THE MECHANICAL PROPERTIES OF AIR.

ONE of the firſt things that our ſenſes inform us of, is, that although THE AIR we breathe is too fine for our *ſight*, it is very obvious to our *touch*. Although we cannot *ſee* the *wind* contained in a bladder, we can readily *feel* its reſiſtance; and though the *hurricane* may want *colour*, we often fatally experience that it does not want *force*. So far the ſlighteſt experience reaches; but by carrying experiment a little farther, we learn that *the air* alſo is HEAVY.

A glaſs veſſel being *emptied of its air*, and accurately weighed, has been found *lighter* than when it was weighed *with the air in it*. Upon computing the *ſuperior weight* of the full veſſel, a *cubic foot of air* is found to weigh *rather more than an ounce*.

Again, if the air be exhauſted out of any veſſel, and this veſſel be ſet with the mouth downwards in water, the *water will riſe up* into the empty ſpace, and fill the inverted glaſs; the external air will in this caſe preſs upon the water ſurrounding the glaſs, and force it up into *the vacuum*; and juſt as the beam of a balance *riſes*, the other extremity having a weight on it, ſo will the water *riſe* in the glaſs, and continue *to riſe* (if the empty glaſs were tall enough) 32 FEET, and NO HIGHER *.

Pipes have been made purpoſely above 32 feet high; in which, upon being exhauſted, the water has always riſen to the height of 32 feet: there it has *conſtantly reſted*, and *never aſcended higher* †.

From this fact we learn therefore the EXACT WEIGHT of *the air*, which preſſing up the water 32 feet, is equal to a column of water of that height, as it is juſt able to raiſe ſuch a column, and no more.

In other words, the ſurface of the earth is every where ſurrounded with *a weight of air*, which is *equivalent* to a flood of water 32 feet deep, or to a covering of 29 inches and an half of quickſilver, which is known, though occupying leſs ſpace, to be juſt as heavy as the former ‡.

Thus we ſee that the air at the ſurface of the earth is juſt as heavy as 32 feet of water, or 29 inches and an half of quickſilver; and it is eaſily found that to raiſe water 32 feet, *will require a weight of* 15 *pounds upon every ſquare inch*.

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* It is on this principle that *pumps* raiſe water.

† Pumps, therefore, raiſe water no higher than 32 feet.

‡ *Barometers* which determine the weight of air are conſtructed on this principle.

Now if we are fond of computations, we have only to calculate *how many ſquare inches* are in the *ſurface* of an ordinary human body, and allowing *every inch* to ſuſtain 15 *pounds*, we may amaze ourſelves at the weight of air we ſuſtain.

It has been computed that our *ordinary load*, though from its *equal preſſure* we are not ſenſible of it, *amounts* to within a little of 20,000 *pounds*. This is wonderful! but it is not by wondering we acquire wiſdom.

Notwithſtanding this be our ordinary load, there are at *different times*, as the barometer ſhews, *ſome variation* *.

The air is not equally heavy at all ſeaſons; but ſometimes it is *lighter*, and ſometimes *more heavy*. This, therefore, makes a *very great difference* in the weight we ſuſtain; and we are actually known, by computation, to carry at one time 4000 pounds of air more than at another†.

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* When the barometer *riſes*, a greater weight of air preſſes up the mercury in the tube, and the clouds uſually aſcend; when the barometer *ſinks*, the weight of incumbent air being leſs, the clouds gravitate below. Hence the *variations* of the barometer denote the *changes* of the weather.

† The effects of a *moiſt* or *dry* air, and the viciſſitudes of *cold* and *hot* winds on the animal body, will be conſidered afterwards.

Again, as in the ſea, a man at the depth of 20 feet, ſuſtains a greater weight of water than a man at the depth of but 10 feet; ſo will a man at the bottom of a deep valley have a greater weight of air over him, than a man at the top of a very high mountain *.

Our conſtitutions ſeem alſo to correſpond with *theſe changes*; they are braced, ſtrong, and vigorous, with a *large body of air* upon them;—they are languid, relaxed, and feeble, when *the air is light*, and refuſes to give our fibres their proper tone †.

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* The art of taking the heights of mountains by the barometer determines this curious point. As the air grows *lighter* the higher we aſcend, the fluid in the tube will *ſink* alſo in due proportion. It is found to *fall* at the rate of the tenth part of an inch for every 90 feet; ſo that in going up a mountain, if the quickſilver has fallen *an inch*, I conclude I am got up an aſcent of near 900 *feet*. GOLDSMITH.

† Other more important effects will be given, when we come to treat *On the Nature of Diſeaſe*. Dr. PITCAIRN, in the year 1687, being at his country ſeat near Edinburgh, in February, on a fairer day than uſual at that ſeaſon, was ſeized with a ſudden bleeding of the noſe after an uncommon faintneſs, and on the next day, on his return to town, he found that the BAROMETER was *lower* at that very hour than either he or his friend Dr GREGORY, who kept a journal of the weather, had ever obſerved it; and that another friend of his, Mr. COCKBURN, profeſſor of philoſophy, had died ſuddenly at the ſame hour by an eruption of blood from the lungs; and alſo five or ſix others of his patients were ſeized with different hæmorrhages. MEAD.

A CHEMICAL TABLE.

SIMPLE BODIES.			COMPOUND BODIES.
Oxygen - - -	and *Caloric*[*], or Fire,	- - - - - -	is OXYGEN GAS, or VITAL AIR; formerly called Dephlogiſticated Air.
Oxygen - - -	and *Carbon*, - -	- - - - - -	is CARBONIC ACID.
Oxygen - - -	and *Phoſphorus*, -	- - - - - -	is PHOSPHORIC ACID.
Oxygen - - -	and *Sulphur*, -	- - - - - -	is SULPHURIC ACID, or Vitriolic Acid.
Oxygen - - -	and *Mercury*, -	- - - - - -	is OXYD OF MERCURY, or Calx of Mercury.
Oxygen - - -	and *Iron*, - -	- - - - - -	is OXYD OF IRON, or Ruſt of Iron.
Oxygen, - - -	*Azot*, - - -	and *Caloric*, - -	is ATMOSPHERIC AIR, or Common Air.
Oxygen, - - -	*Carbon*, - - -	and *Caloric*, - -	is CARBONIC ACID GAS, or Fixed Air.
Azot - - -	and *Hydrogen*, -	- - - - - -	is AMMONIAC, or Alkali.
Hydrogen - -	and *Caloric*, - -	- - - - - -	is HYDROGEN GAS, or Inflammable Air.
Hydrogen, - -	*Carbon*, - - -	and *Caloric*, - -	is HYDROCARBONIC GAS, or Hydrocarbonate.

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[*] *Caloric* is here conſidered as *light*, though in the courſe of this work theſe two bodies will be diſtinguiſhed.

SECT. II.

THE ANCIENT OPINION RESPECTING OUR AIR.

FORTUNATELY for my readers, the chemical knowledge neceſſary firſt to be learnt in order *clearly* to underſtand the INFLUENCE of AIR on the BLOOD, and THENCE on the ANIMAL ECONOMY, compriſes the *moſt beautiful diſcoveries* in that ſcience; *diſcoveries* that have done honour to this age, and have immortalized the names of PRIESTLEY, LAVOISIER, FOURCROY, and CAVENDISH.

The Honourable Mr. BOYLE has conſidered OUR ATMOSPHERE as *one large chemical veſſel*, in which an infinite number of various operations are conſtantly performing. In it all the bodies of the earth are continually ſending up a part of their ſubſtance, by evaporation, to mix in *this great alembic*, and to float a while in common. Here minerals from their loweſt depths aſcend in noxious vapours to make a part of the general maſs; ſeas, rivers, and ſubterraneous ſprings, furniſh their copious ſupplies; plants receive and return their ſhare; and animals, that by living upon conſume this general ſtore, are found to give it back in vaſt quantities when they die.

THE AIR, therefore, which every where preſſes on us, and upon which we ſubſiſt, bears very little reſemblance to that *pure*, *ſimple*, *elementary body* formerly imagined; and which is rather a ſubſtance that can be conceived, than experienced to exiſt.

MODERN CHEMISTRY, however, has made great advances in *this curious reſearch*, and it will ſoon appear that the compoſition of atmoſpherical air has been more *rigorouſly* determined.

Chemiſtry affords two general methods of aſcertaining the conſtituent principles of bodies, the method of ANALYSIS[*], and that of SYNTHESIS[†].

When, for inſtance, by combining *water* with *alkohol*, we form the ſpecies of liquor called BRANDY, we certainly have a right to conclude (by this ſyntheſis) that BRANDY is compoſed of *alkohol* and *water*. And when, by diſtillation of BRANDY, we obtain ſeparate, *water*, and *alkohol* (by this analyſis), our evidence of the conſtituent principles of BRANDY is then rendered complete; and in general it ought to be conſidered as *a principle* in chemical ſcience, never to reſt ſatisfied without *both theſe ſpecies of proofs*.

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[*] From the Greek word αναλυσις. The *ſeparation* of any *compound* into its *ſeveral parts*.

[†] From the Greek word συνθεσις. The *putting together* the *ſeveral parts* of a *compound body*.

SECT. III.

THE MODERN ANALYSIS OF ATMOSPHERIC AIR;

Or its Separation into 2 ELASTIC FLUIDS, { 1. VITAL AIR, 2. AZOTIC AIR.

LAVOISIER'S FAMOUS EXPERIMENT.

THIS illuſtrious chemiſt having placed 83 *grains* of fluid MERCURY in a *retort*, adapted to a *bell glaſs*, which encloſed 100 *cubical inches* of COMMON AIR, he kept up in his furnace a conſtant fire, of ſuch force, as to keep the QUICKSILVER almoſt always at its *boiling point*.

On the ſecond day ſmall RED PARTICLES began to appear on the ſurface of the MERCURY, which gradually increaſed in ſize and number for 4 or 5 days.

Convinced that the *calcination* of the MERCURY after that time did not go on, he extinguiſhed the fire; and when the veſſel was cool, he found in his bell-glaſs, inſtead of 100 *cubical inches of air*, only 86, and therefore A LOSS of 14 *cubical inches* of AIR.

Now, 14 *cubical inches* of AIR weighs 7 *grains*, and the RED PARTICLES, or CALX OF MERCURY, being carefully collected, weighed 90 *grains*. The MERCURY, therefore, by being calcined, had acquired an *increaſe of weight* of 7 *grains*, the *exact weight* of AIR which ſeemed LOST [*].

The 86 *cubical inches* of AIR remaining in the glaſs after this calcination was ended being examined, it was found to poſſeſs THESE DISTINGUISHING PROPERTIES.

An animal being put into it was *ſuffocated* in a few minutes,—and when *a taper* was plunged into it, it was *extinguiſhed*, as if it had been immerſed in water [†].

THIS GAS, or AIR, has been called *phlogiſticated air*, *non-reſpirable air*, *noxious or mephitic air*, *impure air*; but the French chemiſts have preferred the term AZOTIC GAS *(lethal air)* from the Greek words α, *privative*; and ζωη, *life*, as THIS AIR deſtroys life.

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[*] The concluſion is obvious, and in the next experiment we ſhall find, that the 14 *cubical inches of air*, which was *abſorbed* by the MERCURY, and converted it to a CALX, was the *vital* or *reſpirable part* of our air.

[†] Not from any peculiar property of its own, but becauſe the *vital* or *reſpirable part* was abſtracted from it, as will be ſeen from the next experiment.

LAVOISIER'S SECOND EXPERIMENT.

HAVING taken 90 *grains* of the CALX OF MERCURY, the product of the *laſt proceſs*, LAVOISIER put it into a glaſs retort fitted to a proper apparatus for receiving aerial products.

Having applied a *much ſtronger heat* than in the former experiment, he obſerved that at firſt, in proportion as the CALX of MERCURY became heated, the intenſity of its colour augmented; but ſoon after the CALX began gradually to decreaſe in bulk, and in a few minutes *its red colour altogether diſappeared*, and the 90 *grains* of CALX OF MERCURY was converted into the 83 *grains* of RUNNING MERCURY, and 14 *cubical inches* of an AERIAL FLUID paſſed over into the recipient.

Now theſe 14 *cubical inches* of air weighed 7 *grains*, the *exact weight* of the air *conſumed* by the CALCINATION of the MERCURY in the firſt experiment*; and the 83 *grains* of the CALX OF MERCURY *reduced*† to a *metallic ſtate* being examined, had *loſt in weight* 7 *grains*, the

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* Had the 100 *cubical inches* of atmoſpheric air contained a larger ſhare of *oxygen* or *vital air, more* MERCURY would have been *calcined.* For *calcination,* as this experiment ſhews, is nothing more than the *combination* of VITAL AIR with *any metallic* body.

† From the Latin word REDUCO, *to bring back.* REDUCTION is the bringing back a *metal converted to a calx* to its *priſtine ſtate.*

exact weight of the air now obtained. THIS AIR poſſeſſed theſe PECULIAR PROPERTIES.

An animal, being placed in IT, became *remarkably lively*; a *taper* burnt in it with a *dazzling ſplendour*; and *charcoal*, inſtead of conſuming quietly away, as it does in common air, burnt *with a flame*, attended with a decrepitating noiſe, and threw out ſuch a *brilliant light* that the eyes could hardly endure it.

This ſpecies of air was *diſcovered** almoſt at the ſame time by Dr. PRIESTLEY, Mr. SCHEELE, and LAVOISIER.

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* Dr. MAYOW, a philoſopher of the laſt century, undoubtedly was well acquainted with *this ſpecies* of AIR, and has moſt accurately deſcribed it in his works under the denomination of the *nitro-aerial ſpirit*. (See Dr. Beddoes's Analyſis of Mayow's Works). Near about the ſame period Dr. MUNDY, alſo of Oxford, publiſhed a treatiſe on *Vital Air (De Aere Vitali)*, and, if we may credit hiſtory, great advantage was made of this vivifying ſpirit. Boyle relates, "that CORNELIUS DREBELL is affirmed, by many creditable perſons, to have contrived a veſſel for King James I. to be rowed under water; it carried twelve rowers, beſides paſſengers, and was firſt eſſayed in the river Thames; for DREBELL conceived, that it is not the whole body of air, but a certain *ſpiritual part* of it, that fits it for reſpiration; which being ſpent, the remaining air is unable to cheriſh the vital flame reſiding in the heart. So that, beſides the mechanical contrivance of his boat, he had a chemical preparation, which, by unſtopping the veſſels wherein it was contained, the fumes of it would ſpeedily reſtore to the air, fouled by reſpiration, ſuch a proportion of *vital particles*, as would make it again fit for that office." Dr. PRIESTLEY, in 1774, ſeems, without knowledge of theſe obſolete and antiquated, I might ſay, rejected, ideas of MAYOW and MUNDY, to have diſcovered a permanently elaſtic fluid purer than common air; but amidſt the variety of objects in the purſuit of his experimental enquiries, he then overlooked, or rather neglected to conſider the phænomena of this wonderful fluid, which by chance, of modern philoſophers,

SIER. Dr. PRIESTLEY gave it the name of *Dephlogiſticated* or *Pure Air*; Mr. SHEELE called it *Empyreal Air*; and LAVOISIER firſt named it *Highly reſpirable Air*, or *Vital Air*; and afterwards, as it forms acids, by combining with certain bodies, the French chemiſts adopted the term OXYGEN GAS *(Acid-making Air)*, from the Greek words υξυς, *ſour*; and γεινομαι, *to beget**.

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philoſophers, was firſt preſented to his view. Nearly about the time that Dr. PRIESTLEY diſcovered the *Dephlogiſticated air* in England, Mr. SHEELE, of Sweden, was engaged in making experiments on air and fire, which he publiſhed in German; and in thoſe experiments we find alſo the diſcovery of *vital air*, called by Mr. SCHEELE, *Empyreal air*; both of whom appear wholly unacquainted with each other's diſcovery, which is confirmed by each of theſe philoſophers arriving at the ſame *concluſion* by different roads: but undoubtedly LAVOISIER was the *firſt* who proved, by direct and exact experiments, that the weight which metals gain by *calcination* correſponds with that of the air which they abſorb; he was the *firſt* who aſcertained, by the moſt deciſive experiments, that the atmoſphere conſiſts of *two diſtinct fluids*, the *one* fit for the purpoſes of reſpiration and combuſtion, which he therefore called VITAL, or PURE AIR; the *other* unfit for either purpoſe, and thence called FOUL, or MEPHITIC AIR; he *firſt* proved that PURE VITAL AIR contained more FIRE, or CALORIC, than any other air; and that during combuſtion, as this air, or rather its *baſe*, was uniting to the ſubſtance, and adding its weight to the burning body, it gave out this FIRE in the form of HEAT and LIGHT.

* If *ſulphur* or *charcoal* be burnt in *oxygen* or *vital air*, in a cloſe veſſel, and the fumes be condenſed in water, *this water* will acquire an ACID TASTE, and be increaſed *in weight* exactly *correſponding* to the *weights* of *ſulphur* or *charcoal* conſumed, and *that* of the *oxygen air* deſtroyed. *Sulphur* united thus with *oxygen*, the fumes being collected in water, will form VITRIOLIC ACID; and *charcoal* combined with *oxygen*, and diffuſed in water, will form SELTZAR, or the AERIAL ACID WATER. The *calces* of metals the French chemiſts call OXYDS, which ſignifies a body impregnated with a *certain quantity* of *oxygen*, but not *ſufficient* to render it *perceptibly acid*.

THE SYNTHESIS.

Lavoisier then repeated the ſame experiments as before related, and *re-combined* the 2 ELASTIC FLUIDS, which he had ſeparately obtained in the two experiments of *calcination* and *reduction*, viz. the 84 *cubical inches* of the AZOTIC AIR, and the 14 *cubical inches* of the OXYGEN AIR, and he produced from *this combination* an ELASTIC FLUID *preciſely ſimilar in all its properties to* ATMOSPHERIC AIR, contributing in the ſame way to a repetition of the ſame experiments, and poſſeſſing the ſame power of ſupporting animal life and combuſtion.

The philoſopher can have no remaining doubt as to the *compoſition* of ATMOSPHERIC AIR: but the circumſtances of theſe experiments might appear to him *more correct*, though probably at the time *leſs clear* to others, were it ſaid, that MERCURY, at a certain temperature, overcoming the affinities* of *caloric* † and *azotic air* for

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* If you take a bullet and divide it with a knife into *two parts*, provided theſe be ſmooth and rubbed together, they will ſtrongly unite and form *one whole*. This is from a law impreſſed on matter called the *attraction of coheſion*. But ſhould a particle of ſand, or any roughneſs exiſt, the particles being divorced

† *Fire*, or the *matter of heat*.

OXYGEN, attracts and fixes within itſelf OXYGEN*, (the *baſe* of oxygen air, for oxygen air is oxygen combined with a certain quantity of caloric:)—hence its *increaſe of weight*, and its *converſion into an oxyd or calx*, and hence the AZOTIC, OR LETHAL, AIR *left us* in the bell-glaſs.—That, the temperature being increaſed†, the affinity of

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divorced from each other, beyond the *ſphere of mutual attraction,* they are no longer actuated by this law.—*The attraction of coheſion* in *mercury,* at the common temperature, hinders the admiſſion of OXYGEN, for which it has an *elective attraction* or *affinity*. But when expoſed to a ſtrong heat, the *caloric* expands this fluid; that is, inſinuates itſelf through the body, and ſeparates its particles (thermometers depend on this expanſive power of fire), and, like the pieces of the bullet where ſand interpoſed, the divided particles are no longer ſubject to the *law of coheſion*; then it is they obey the *law of attraction,* and each atom of MERCURY *attracts to itſelf* a particle of OXYGEN, juſt as a loadſtone would draw to itſelf a particle of iron.—The loadſtone *only attracts* iron. This repreſents the term *affinity* in chemiſtry. The mercury did not attract the AZOT, becauſe chemiſts would ſay it had no *affinity* for it.

[*] An experimentaliſt would illuſtrate this by placing a NEEDLE between *two magnets* of different powers. This would repreſent OXYGEN between the two attractions of the *caloric* and *azotic air.* As we may ſuppoſe a *loadſtone* to have an attraction for the NEEDLE ſuperior to the *two magnets,* ſo would it draw THE NEEDLE to itſelf from *theſe,* juſt as the *mercury* draws away from the *azotic air* and *caloric,* the OXYGEN.

[†] This is a curious fact; the temperature being increaſed, the CALORIC *alone* overcomes the elective attraction of *mercury* for *oxygen,* and depriving it of *that principle,* the *attraction of coheſion* takes place with the particles of *mercury,* and we obtain then RUNNING MERCURY and OXYGEN GAS. To have recourſe to the note on page 12, the *oxygen* and *mercury* being ſeparated beyond their *ſphere of attraction,* the *caloric* attracts to itſelf *oxygen,* juſt as either of the *magnets* (in the preceding note) would again attract to itſelf the NEEDLE, were it placed within its *ſphere of attraction,* but *beyond that* of the *loadſtone.*

the *caloric* for OXYGEN becoming now ſuperior to the attraction of the MERCURY, the OXYGEN is withdrawn from the OXYD OF MERCURY by the ſuperior attraction of the *caloric* ;—hence its *decreaſe in weight*, and its *reſtoration to fluidity and ſplendour*, and hence the produce of OXYGEN, or VITAL, AIR, clearly diſplaying to us this important truth.

"THAT ATMOSPHERIC AIR IS ACTUALLY A "COMPOUND OF TWO HEAVY SUBSTANCES, AZOT* "AND OXYGEN; WHICH BODIES, WHEN COMBINED "WITH CALORIC, OR THE MATTER OF HEAT, "ARE AERIFORM, AND MAY BE PROCURED IN "SEPARATE STATES, viz. IN THE CONDITION OF "VITAL, AND AZOTIC, AIR, WHICH BEING MIXED "IN A CERTAIN PROPORTION CONSTITUTES OUR "ATMOSPHERE."

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* That AZOT is a *ſolid ſubſtance* as well as OXYGEN, can be eaſily proved by experiment, conſult page 39. That the application of heat ſhould render *oxygen*, and *azot*, *gaſeous* is not wonderful, ſince we often obſerve *ice* by the admixture of *caloric* rendered a *fluid*, and heated to 212, converted into an aeriform and tranſparent gas. The hardeſt ſubſtance in the world, the DIAMOND, may be volatilized in the ſame way. Mon. D'Arcet took a ſphere of porcelain china, and after cutting it into halves, confined a *diamond* in the middle; he then joined the two ſections ſtrongly together. Putting theſe balls into a furnace, he afterwards unſcrewed them, and found the diamonds evaporated, and the place which they occupied empty, though he could perceive no chink or fracture any where over the ſurface of the ball!

Although theſe experiments furniſh us with a very ſimple means of obtaining, ſeparate from each other, the two elaſtic fluids which compoſe our atmoſphere, yet do they not give us an exact idea of *the proportion* in which *theſe two* enter *its compoſition* *. For the attraction of the MERCURY for OXYGEN is not ſufficiently ſtrong to overcome all the circumſtances which oppoſe this union, ſuch as the mutual adheſion of the *oxygen* and *azotic airs*, and the ſtrong affinity which unites *oxygen* to *caloric*; in conſequence of theſe, though the OXYGEN torn by the MERCURY from its union with the *azotic air* is more abundant, there will ſtill remain ſome portion of the *oxygenous principle*, combined with the *azotic air*, which the MERCURY could not ſeparate.

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* In our climate the proportion generally is 4 of *azotic air* to 1 of *oxygen air*, as will be hereafter proved.

SECT. IV.

THE ANALYSIS
OF
OXYGEN AIR.

That oxygen gas, is compoſed of
1. OXYGEN,
2. CALORIC,
3. LIGHT,

will be *evident* from the following very elegant experiment firſt made by the celebrated Dr. Ingenhousz.

A fine *iron wire*, twiſted into a ſpiral *, being heated at its extremity red hot, and thruſt into a jar containing only *oxygen air*, it inſtantly took fire, and burnt away rapidly †, exhibiting a bright light ſimilar to that of Chineſe fire-works, throwing out brilliant ſparks, which fell to the bottom in the form of round globules ‡.

At the beginning of the combuſtion there is a ſlight augmentation in the volume of the air in the bell-glaſs, from the dilation cauſed by the caloric or heat; but preſently after a *rapid diminution* takes place, and *the mercury riſes in the glaſs*, inſomuch that when the *quantity of iron is ſufficient*, and the OXYGEN AIR *operated on is very pure*, almoſt the *whole air employed* is *abſorbed*[*],—or ſhould the *quantity of* IRON *be inſufficient*, the REMAINING AIR *unabſorbed* will be found PERFECTLY PURE VITAL AIR[†].

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* This was done to render the experiment more ſtriking.

† This experiment ſhews that *azotic air* retards the union of *oxygen* with bodies attracting it, which in ſome caſes altogether prevents it.

‡ Theſe were found floating on the mercury, and are natural *Martial Æthiops*. How much ſlower is the *calcination* or *ruſting* of *iron* in other circumſtances!

The *theory* of this experiment is the ſame as the laſt. At a certain temperature IRON has a *ſtronger affinity* for the OXYGEN, than CALORIC and LIGHT have. It *therefore* attracts to itſelf the OXYGEN, and CALORIC and LIGHT becoming diſengaged[‡], are rendered *active* and *evident* to the ſenſes.

SECT.

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[*] That is, if 100 *grains* of IRON be conſumed in 70 *cubic inches of oxygen air*, the whole volume of air will diſappear; and as 70 *cubic inches* of *oxygen air* weigh 35 grains, the 100 *grains* of *iron* will weigh, in its ſtate of *oxyd* or *calx*, 135 grains.

[†] As the *pure* or *oxygen air* is found unaltered, the *mephitic air* left us in the *calcination of the mercury* could ariſe only from the *abſtraction* of the *oxygen air*. Vide Experiment the Firſt, p 8, note *.

[‡] As the calcination of the *mercury*, in the firſt experiment, laſted ſeveral days, the *diſengagement* of CALORIC and LIGHT was extremely ſmall for each particular moment of time, and therefore not perceptible to the ſight. The heat, alſo, of the furnace was confounded with it, which made it neceſſary to relate Dr. INGENHOUSZ's experiment, where *the combuſtion* of the metal was more rapid, and unconnected with any furnace.

The burning of all bodies is then nothing more than the *decompoſition* of *oxygen air*. It is the *air*, therefore, and not the combuſtible body, that gives out *light* and *heat*. When we are ſailing on the water in a ſtill day, *diſtinct objects appear to meet*

SECT. V.

THE ANALYSIS OF WATER;

Or its ſeparation into its 2 CONSTITUENT PARTS, { 1. HYDROGEN,
2. OXYGEN.

PREVIOUS to our entering upon the ſubject of the effects of air on the animal economy, it will be neceſſary to ſhew, alſo, that WATER, though it be the ſolvent of a vaſt variety of bodies, is neither that *compound* or *ſimple element* formerly ſuppoſed, but made up of two VERY DISTINCT and DIFFERENT PRINCIPLES.

The new and beautiful doctrine of the French chemiſts, reſpecting the compoſition of *air*, the nature of *combuſtion*, *calcination*, &c. was daily gaining ground, and obtaining the applauſe of every one, when an expe-

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meet us, but our reaſon corrects the deluſion. When we behold the ſun, moving from eaſt to weſt, philoſophy again aſſumes its empire, and we are convinced it is *ſtationary*. If we take a PRISM, it diſplays to us a variety of colours; our reaſon tells us here alſo, that *theſe colours* ariſe from the RAYS OF LIGHT, and are not *in* THE PRISM,—ſo of the combuſtion of bodies, the *caloric* and *light* are not from THE WAX of our candles, but from the OXYGEN AIR, which, as we have ſeen in this experiment, becomes, under certain circumſtances, *decompoſed*.

riment performed by Dr. PRIESTLEY made it for a while totter on its baſis.

In the middle of a long glaſs tube this great experimentaliſt put ſome CALCINED LEAD, and affixed to the extremities *bladders* which were filled with INFAMMABLE AIR *. Having applied a ſtrong heat to the middle of this tube, he next ſqueezed the bladders, and forced the INFLAMMABLE AIR along the tube.

The INFLAMMABLE AIR ſoon diſappeared: no OXYGEN GAS was evolved: but the RED LEAD quickly *reaſſumed* its original metallic ſplendour.

A queſtion then aroſe, whence *this property* in INFLAMMABLE AIR which the ANTIPHLOGISTIANS would aſcribe to the evolution of OXYGEN GAS †.

The favourers of the NEW SYSTEM were not able to deny the fact; and as the INFLAMMABLE AIR, which was now called PHLOGISTON, had in this experiment

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* *This air* Dr. PRIESTLEY obtained from *diluted* vitriolic acid poured on iron. *Iron* was therefore ſaid to contain a great quantity of *this air.* But the fact will ſoon appear that the air aroſe from the *decompoſition of the water* mixed with the vitriolic acid. INFLAMMABLE, or HYDROGEN, AIR, being 15 times lighter than common air, it is employed for balloons.

† *Inflammable air* quickly deſtroys life, whereas *oxygen gas* appears to be the very principle of life. *It* is conſiderably lighter than either *oxygen* or *common air. It* explodes when it comes into contact with *common air,* but more eſpecially with *oxygen air,* provided any body in actual inflammation be preſent. The difference therefore between theſe two airs is great.

diſappeared, they found ſome difficulty to perſuade *the ſupporters of the* OLD DOCTRINE that the *revival of the metal* could not be from the *abſorption* of the INFLAMMABLE AIR, as the RED LEAD had *loſt* a good deal of its *weight*, and the *effect* of an *addition of matter* (if *inflammable air* be *matter*) could be no other than to give it *an increaſe* of *weight*.

Fortunately for chemiſtry the Honourable Mr. CAVENDISH, by paſſing an electric ſhock through *oxygen air* blended with *inflammable air*, produced WATER [*]. *The reduction* of the RED LEAD in Dr. PRIESTLEY's experiment was then no longer a matter of ſurpriſe. At a *certain temperature* the INFLAMMABLE AIR overcoming the attraction of the *lead* for OXYGEN divorced it of *that principle*, and uniting with it formed WATER [†].

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[*] 85 grains, by weight, of *oxygen air*, and 15 grains of *inflammable* or *hydrogen air*, produced here preciſely 100 grains of WATER. In this experiment *caloric* is diſengaged, and the 85 parts of *oxygen* and 15 of *hydrogen* unite, which, being naturally *ſolid ſubſtances of themſelves*, become, if nearly all the *caloric* be extracted from them, ICE; if leſs, WATER.

[†] WATER and AIR, ſays Sir ISAAC NEWTON, compoſed of old worn particles and fragments of particles, would not be of the ſame *texture* and *nature* now as at the beginning, did not the *primitive particles* of MATTER continue *entire*, and *compoſe bodies* of *one* and the *ſame nature and texture in all ages*. The *changes* of *corporeal things* are to be placed *only* in the *various ſeparations* and *new aſſociations* of *theſe* PERMANENT PARTICLES. OPTICS, p. 376. How beautifully has modern chemiſtry confirmed this great man's ideas!

But that no doubt may be entertained on this head, I muſt beg leave to relate an experiment which was performed by MEUSNIER before a large aſſembly of the Academy of Sciences at Paris.

He took a GUN-BARREL, into which he put ſome thick pieces of IRON-WIRE flattened by the hammer. He *weighed* the whole with a ſcrupulous exactneſs. He then *luted* the gun-barrel to ſecure it from the immediate contact of the fire. It was then placed in *a furnace*, but ſo *inclined* that water would readily glide down it, He adopted to the upper extremity a *funnel* containing water, from which it could not eſcape into the gun-barrel but drop by drop. This funnel was *cloſed at the top* to avoid any the leaſt evaporation of the water. At the lower extremity *veſſels* were adapted to receive any aerial product. To uſe every precaution *theſe* were exhauſted of their air.

The *gun-barrel* was now made red hot, and the WATER from the funnel paſſed into it drop by drop.

An aſtoniſhing quantity of INFLAMMABLE AIR* was quickly obtained.

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* This INFLAMMABLE AIR was generated from the *hydrogen* of the water, which united with the *caloric* of the furnace in its paſſage through the barrel. INFLAMMABLE AIR the French chemiſts call HYDROGEN GAS, from the Greek words *υδωρ water*, and *γεινομαι to beget.*

Having removed the luting, the *gun-barrel* with its *contents* weighed conſiderably *heavier* than *before*; and *the acquired weight* of the gun-barrel being *added* to the *weight* of the *inflammable air* thus produced, was *preciſely* the *weight* of the WATER *expended* in the proceſs: and the IRON-WIRE found in the barrel (the proceſs being over) reſembled in every reſpect *iron* that has been conſumed in *oxygen air*, that is, it was become an OXYD* OF IRON, which accounts for the *oxygen*, the other conſtituent principle of water.

Another proof that WATER is compoſed of *hydrogen* and *oxygen* may be drawn from the celebrated experiment of Mr. WATT. This illuſtrious chemiſt wet powdered charcoal, and put it ſo moiſtened into a retort. Fire being applied, HYDROCARBONATE AIR * is ſoon formed; that is, *hydrogen air*, or *inflammable air*, mixed with fixed air, which, in the next ſection, we ſhall find is compoſed of charcoal and *oxygen*.

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* This air, which is applied medicinally, was the happy diſcovery of Mr. WATT. This benevolent philoſopher alſo taught phyſicians an eaſy proceſs for obtaining VITAL AIR. His ſimple apparatus is a furnace, in which is placed an iron retort filled with finely powdered *mangane∫e*. An iron gun-barrel enters the mouth of the retort, and at its other extremity is connected with his *pneumatic receiver*, or with any veſſel filled with, and immerſed over, water. The furnace is then filled with charcoal and lighted, and VITAL AIR is obtained very rapidly, and in conſiderable quantity. The luting that Dr. THORNTON diſcovered to be the beſt, is putty mixed with ſand.

SECT. VI.

THE ANALYSIS OF CARBONIC ACID AIR, OR FIXED AIR;

Or its ſeparation into its 2 CONSTITUENT PARTS, { 1. CHARCOAL, 2. OXYGEN AIR.

MR. TENANT, a famous chemiſt of Emanuel College, Cambridge, having procured a glaſs tube hermetically ſealed at one end, luted it over with clay and ſand to prevent the ſudden action of the fire. He then introduced into it ſome PHOSPHORUS and powdered MARBLE[*], and having cloſed the open extremity, he applied to the tube a quick heat, and the reſult was, when cold,

1. PHOSPHORIC ACID[†] combined with *calcareous earth.*

2. PHOSPHORUS combined with the *ſame earth.* And

3. A BLACK SUBSTANCE, which differed in nothing from CHARCOAL made from vegetables.

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[*] If *vitriolic acid* be poured on *marble,* FIXED AIR is given out in great abundance. Mr. TENANT therefore aſſumes this data, *that marble contains* FIXED AIR. As the reſidue is *vitriolic acid* and CALCAREOUS EARTH, *marble* is known alſo to contain CALCAREOUS EARTH.

[†] *Phoſphorus* and *oxygen.* The anſwer to this natural queſtion, *Whence this oxygen?* is clearly demonſtrated over leaf.

If VITRIOLIC ACID * be poured on MARBLE, THIS ACID poſſeſſing a ſuperior power of combination or attraction for the *calcareous earth* of the marble, than the *carbonic acid* † has, it unites with the *calcareous earth*, and the *carbonic acid*, becoming diſengaged, attracts to itſelf *caloric* ‡, and eſcapes in the form of *gas* ‖.

MARBLE is therefore a compound of 3 *bodies*,
1. OXYGEN, combined with
2. CHARCOAL, or *the carbonic acid*; and
3. CALCAREOUS EARTH.

The *theory of* Mr. TENANT's *experiment* will be now eaſily underſtood.

At a certain temperature PHOSPHORUS (which is a ſimple body) overcoming the attraction of the *charcoal* for *oxygen*, deprives the CARBONIC ACID of its *oxygen*, and becomes, in conſequence,

1. PHOSPHORIC ACID §, which unites with the *calcareous earth*.

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* *Sulphur* and *oxygen*.

† *Charcoal* and *oxygen*. FIXED AIR is *charcoal*, *oxygen*, and CALORIC.

‡ The CALORIC proceeds in part from the *vitriolic acid*; which acid, if poured on *water*, will almoſt make it *boiling hot*, to the no ſmall aſtoniſhment of perſons unacquainted with chemical operations. Since *two cold bodies*, coming into contact with each other, give out *heat*, CALORIC, we ſee, may be in a *dormant* or *neutralized ſtate*.

‖ Viz. CARBONIC ACID GAS, or FIXED AIR; which is *charcoal* (carbon), *oxygen*, and a certain quantity of *caloric*. Vide p. 23, note *.

§ *Phoſphorus* and *oxygen*.

The *phoſphoric acid* being *ſaturated*[*] with the *calcareous earth*, we have alſo,

2. PHOSPHORUS united with *calcareous earth*. And,

3. The CHARCOAL of the marble is left us in its *ſimple ſtate*[†].

The proof, however, by ſyntheſis, that the conſtituent principles of FIXED AIR, are *charcoal*, and *oxygen* AIR, is more beautiful, as being eaſier underſtood.

THE SYNTHESIS.

THIS CHARCOAL[‡] Mr. TENANT then burnt in *oxygen air*, which was converted into an ACID GAS, whoſe *weight* equalled the ſum of the *weights* of the *charcoal* which had been burnt, and the *oxygen air* employed[||].

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[*] If *diluted vitriolic acid* be poured on marble, an efferveſcence denoting the extrication of *fixed air* is ſeen; when the union of the *vitriolic acid* and *calcareous earth* is *complete*, it is ſaid to be SATURATED, the efferveſcence now ceaſing.

[†] The OXYGEN, with which it was before combined, being ſeparated from it, by the *ſuperior attraction* of the PHOSPHORUS.

[‡] ANY CHARCOAL would have had the ſame effect.

[||] FIXED AIR, or the CARBONIC ACID AIR, is compoſed of 28 parts of CHARCOAL to 72 of OXYGEN AIR; or, in other words, 144 cubic inches of *oxygen air* will ſaturate or take up 28 grains of *charcoal*.

THIS ACID GAS had all the *properties* of FIXED AIR. It was readily upon agitation *imbibed by water* *, which acquired the ſparkling appearance and taſte of Pyrmont and Seltzer water. *This acidulated water* diſſolved iron filings, and became a perfect chalybeate water. THIS AIR, like FIXED AIR, weighed *heavier* than *common air*. A *candle* being put in it, was quickly *extinguiſhed*, and *an animal* died *convulſed in it*.

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* We owe our firſt knowledge of FIXED AIR to Dr. BLACK, but that *water* abſorbed *this air* upon agitation, and was made Seltzer or Pyrmont water, and that if *iron filings* be put into *this acidulated water*, it becomes a *chalybeate*, we are indebted to the happy induſtry of Dr. PRIESTLEY.

The reader, from the above account, may wiſh to know how FIXED AIR *(charcoal, oxygen,* and *caloric)*, differs from CARBONIC ACID *(charcoal* and *oxygen)*. We ſee, indeed, *water* abſorbing a large bulk of FIXED AIR. But does not ſome portion of its *caloric* paſs into the *cold water*, and hence the condenſation (if I may be allowed the expreſſion) of the FIXED AIR; for if a ſmall heat be applied to the *aeriated water*, it parts with its FIXED AIR. The ſubject is yet ſomewhat obſcure. If *ſulphur* be burnt in *oxygen air (oxygen* and *caloric)*, VITRIOLIC ACID is gradually formed from the combination of the *ſulphur* with the *oxygen*, and the *caloric* is diſengaged. If *hydrogen* or *inflammable air* be burnt in *oxygen air*, the combination of the *hydrogen* with the *oxygen* is very rapid, and WATER is formed, and *the caloric* is ſuddenly diſengaged: but if VITRIOLIC ACID be poured on WATER, a conſiderable quantity of *caloric* is then *alſo* diſengaged, which ſeems to prove, that *in the condenſation of airs*, on their change into *ſolid ſubſtances*, only a *portion* of their CALORIC is diſengaged.

SECT. VII.

THE ANALYSIS OF ADEPS, OR ANIMAL FAT;

Or its Separation into its 2 CONSTITUENT PARTS, { HYDROGEN, and CHARCOAL.

ANIMAL SUBSTANCES give the ſame products in diſtillation as the *cruciform* * tribe of plants, viz.

ELEMENTS.

	1.	2.	3.	4.	5.
1. WATER, - -	*oxygen,*	& *hydrogen,*	- -		
2. OIL, - - -	- -	*hydrogen,*	& *charcoal,*		
3. CARBONIC ACID,	*oxygen,*	- -	& *charcoal,*		
4. CHARCOAL, -	- -	- -	- -		
5. PHOSPHORATED CHARCOAL,	- -	- -	*charcoal,*	& *phoſphorus.*	
6. AMMONIAC, -	- -	*hydrogen,*	- -	- -	& *Azot.*

But as theſe ſubſtances contain more *hydrogen* and *azot* than ſuch vegetables, they therefore produce a greater quantity of OIL and AMMONIAC.

That

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* From moſt vegetable ſubſtances, excepting the cruciform plants, we obtain, by ſlow diſtillation,

EXPERIMENT I.

	ELEMENTS.		
	1.	2.	3.
1. WATER, - -	*oxygen,*	& *hydrogen.*	
2. OIL, - - -	- -	*hydrogen,*	& *charcoal* (as will be proved).
3. CARBONIC ACID,	*oxygen,*	- -	& *charcoal.*
4. CHARCOAL.			

or, in other words, we obtain WATER acidulated with CARBONIC ACID, on the ſurface of which floats ESSENTIAL OIL,—and there remains in the retort, unvolatilized by *caloric,* CARBON or CHARCOAL.

But had the heat at firſt been conſiderable in the furnace, we ſhould have had *from the ſame materials,* inſtead of WATER,

EXPERIMENT II.

	ELEMENTS.			From the furnace.
	1.	2.	3.	4.
1. CARBONIC ACID GAS,	*oxygen,*	- -	*charcoal,*	& *caloric.*

The *oxygen* under theſe circumſtances has a greater affinity for *carbon* than for *hydrogen.* And inſtead of OIL,

	1.	2.	3.	4.
2. HYDROGEN GAS, -	- -	*hydrogen,*	- -	& *caloric.*

The *hydrogen* having in this caſe a greater affinity for *caloric* than for *charcoal.* And,

3. CHARCOAL.

It is an axiom in chemiſtry, that in all its operations nothing is *created,* but only a new *arrangement of parts* takes place: for *the quantity of matter* ſtill remains the ſame after every proceſs.

In the SECOND EXPERIMENT we have ſeen *vegetable matter* reduced to *its primeval elements,* HYDROGEN, OXYGEN, and CHARCOAL. If we carefully aſcertain the quantity of HYDROGEN and CHARCOAL produced in the firſt experiment, and *compare this quantity* with the quantity of HYDROGEN and CHARCOAL produced in the ſecond experiment, we ſhall find a *loſs* or *deficiency* of theſe *two ſimple elements* in the produce of the FIRST EXPERIMENT, which correſponds exactly with *the weight* of the OIL.

VEGETABLE OIL is compoſed therefore of HYDROGEN and CHARCOAL.

That ANIMAL OIL or ADEPS is compoſed, like VEGETABLE OIL, of *charcoal* and *hydrogen*, will appear evident from the following *analyſis*, or ſeparation of ANIMAL OIL into its conſtituent principles.

In the firſt rectification of *animal oil* a ſmall quantity of WATER is formed by the union of the *oxygen* contained in the air of the diſtilling veſſel, and the *hydrogen* of the oil. We can at length, by frequent diſtillations, decompoſe the *whole oil*, and convert it into WATER *(oxygen* and *hydrogen)* and CHARCOAL, and the weights of the CHARCOAL and WATER will be found exactly correſponding with thoſe of the OIL and the OXYGEN AIR conſumed.

I cannot help here obſerving the uſe that vegetation is of to animal life as firſt diſcovered by Dr. INGENHOUSZ, in furniſhing the atmoſphere during the day with abundance of VITAL or OXYGEN AIR. Dr. PRIESTLEY's experiments likewiſe prove that vegetables abſorb the NOXIOUS AIR *(fixed air)* produced from combuſtion, reſpiration, and putrefaction; for which diſcovery he received the thanks of the Royal Society

Dr. FRANKLIN, in writing to this illuſtrious experimentaliſt, ſays, " That the *vegetable creation* ſhould reſtore the air, which has been ſpoilt by the *animal part of it*, looks like a rational ſyſtem, and ſeems to be of a piece with the reſt." Having obſerved the rapid increaſe that plants had in *air fatal* to animals (fixed air), he adds, " This ſeems to prove that ſomething is taken from the air."

It now appears that the veſſels on the under ſurface of leaves abſorb WATER from the air, which paſſing along the capillary tubes of the ſuperior ſurface, by the action of the *ſun*, and the influence of *light*, becomes decompoſed, and the HYDROGEN of the *water* unites with the *ſubſtance* of the plant as one of its principles, while the ſuperabundant OXYGEN is thrown out in the form of the PUREST VITAL, or OXYGEN GAS.

But ſhould the reader have any remaining doubts on this ſubject, he will be convinced by the peruſal of the following *curious account.*

By an arrêt from government *the burying ground* of the Innocents at Paris, which had been the common receptacle of a great part of the dead of that city for *many centuries*, was directed to be removed. It was compoſed of different burying-places. This name was given to excavations about 30 feet deep, and 20 in breadth, dug in the cemetery of the Innocents, in which were placed in tiers the bodies of the poor, encloſed in their coffins. The neceſſity they were under of aggregating together a great number, obliged the men employed in this buſineſs to place the coffins ſo near to each other, that theſe graves may be conceived as filled with a maſs of dead bodies, ſeparated from each other only by ſlight boards. Each of theſe graves contained about 1500 bodies. When full, the laſt row was covered with about a foot of earth, and a new cavity was opened at ſome diſtance. Each cavity was filled in about three years. The number of the dead, relative to the extent of the church-yard, regulated the *re-opening* of the *ſame ground* at periods of various extent. The ſhorteſt time, however, before an opening was made in the ſame ſpot was 15 *years*. Experience had taught theſe grave-diggers that *this period* was not ſufficient for the total deſtruction of the bodies, whilſt it made them acquainted with the change which we are about to deſcribe.

The opening which the *French chemiſts* ordered to be firſt made, was that of a grave which had been filled and cloſed up for near 15 years. On raiſing the covers of ſome of the coffins, which were in perfect preſervation, we ſaw, ſay they, the bodies enveloped in linen, which marked out the ſhapes of the different regions; but when theſe were lifted up, there was preſented to us nothing but *ſhapeleſs irregular maſſes of a ſoft, ductile, whitiſh ſubſtance.*

Theſe maſſes every where ſurrounded the bones. They poſſeſſed little ſolidity, and yielded to preſſure. This ſubſtance had no unpleaſant ſmell. The grave-diggers had not the ſmalleſt repugnance to handle it, and they called this ſubſtance, which ſo much ſtartled the French philoſophers, by the term FAT.

After examining ſeveral bodies with great attention, they found that all the bodies were not *equally advanced* in this proceſs. In *ſeveral*, *portions of muſcular fleſh*, diſtinguiſhed by its *fibrous texture* and *reddiſh colour*, were ſtill viſible, amid great maſſes of a WHITE FATTY SUBSTANCE.

In the bodies of women, the exterior part of the cheſt often ſhewed the glandular ſubſtance of the *breaſts*, changed into an homogeneous matter of peculiar whiteneſs, very much reſembling SPERMACETI. The *face* was not recogniſable in the greater number of bodies. The various parts of the *mouth* were not to be diſtinguiſhed. The *jaws*, ſeparate from each other, were ſurrounded with various portions of fat, and lumps of the ſame matter occupied the *cavity of the mouth*. The cartilages of the *noſe* underwent a ſimilar alteration. In the place of *eyes*, the orbits contained only maſſes of fat; and the *ears* were changed in a ſimilar manner. The *hairy ſcalp*, though altered like the other parts, ſtill retained the hair. The *brain* was conſtantly found changed into the ſame ſubſtance as the other organs.

In the *abdomen* there were found irregular maſſes of the ſame fat of various ſizes. In the *thorax* were ſmall pieces of a fatty matter, of a reddiſh colour; and ſometimes there were obſerved irregular round maſſes, which ſeemed to be formed of the fat and fibres of the heart.

The *marrow*, alſo, in the center of the cylindrical bones was wholly converted into a very pure fat; it even inſinuated itſelf between the bony plates, filling up their interſtices.

Although there is no doubt but that the quantity of this matter is larger in the bodies of ſuch as have been fat than in thoſe who have been lean, the facts we have mentioned prove that other parts, beſides the cellular texture, and fat it contains, are ſuſceptible of this alteration. The following obſervations are deciſive with regard to this point. It is to be preſumed, that the greater number of bodies found in this common grave, were, previous to their death, emaciated by diſeaſe, and in theſe the bodies were found *univerſally* converted into fat, which we cannot ſuppoſe to have had a previous exiſtence.

Our curioſity was ſufficiently rouſed, continue theſe chemiſts, to extend our reſearches into other church-yards. In thoſe, where bodies were buried in common graves, we found ſimilar appearances. We met with the fatty matter in a ſufficient variety of cemeteries to convince us, that the formation of this ſingular ſubſtance was by no means peculiar to the ſoil in which we had at firſt obſerved it, but that it takes place every where,

where bodies are depoſited in great numbers, cloſe to one another, excluded from the action of external agents, and expoſed ſolely to the effects of their conſtituent principles.

We could obtain no poſitive information relative to what became of the bodies after they have been once changed into fat; the oldeſt and moſt experienced gravedigger knew nothing of this matter.

This converſion of the ſeveral parts of the human body into *true animal fat*, muſt ariſe, ſays Monſ. **LAVOISIER**, from the diſengagement of **AZOT**, naturally contained in all animal ſubſtances, leaving behind the HYDROGEN and CARBON, which are the elements proper for the production of FAT or OIL *.

Such are the phenomena taking place during the ſpontaneous diſſolution of bodies buried in the earth; phenomena heretofore equally unknown and undeſcribed, ſo that even words were wanting to convey our ideas. The preſent muſt merely be conſidered as a very imperfect outline of the picture, which poſterity muſt fill up and finiſh. For this purpoſe it will be neceſſary to live among the tombs, to follow up a long and repeated examination of various graves, and beſtow indefatigable attention on the moſt unpleaſant, as well as the moſt melancholy of all purſuits. But even theſe obſervations, which an accident, fortunate for philoſophy, created, deſerve we think a place among the records of uſeful ſcience *.

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* If *nitrous acid* be poured upon *lean meat* AZOTIC GAS is plentifully diſengaged, and in three days it is changed into a fatty matter, reſembling *ſpermaceti*. **LAVOISIER** thinks that this diſcovery may hereafter prove of great ſervice to ſociety.

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* Dr. **Gibbes**, and the Rev. Mr. **Townsend**, found that lean beef ſecured in a running ſtream was converted into this fatty matter at the end of a month. The latter having a cow killed by an accident, buried it in a water meadow at Pewſey. The grave was but ſlightly covered with earth, and a conſtant ſtream of freſh water continually paſſed over it. *Spermaceti*, or a ſubſtance much reſembling it, was formed, and the experiment promiſes to be of advantage to the community.—Shall I not excite an emotion of ridicule, when I mention that, as the fleſh is capable of being changed into ſpermaceti, the bones are at the ſame time capable of being converted into a pure *glaſs*. The illuſtrious **Becker**, father of the Phlogiſtic ſchool, was long ago perfectly acquainted with this fact. He tells, in determinate language, "Homo vitrum eſt, et in vitrum redigi poteſt, ſicut et omnia "animalia." He regrets that the Scythians, who drank out of diſguſting ſculls, were not acquainted with the art of converting them into glaſs. *Phoſphorus*, which amuſes while it aſtoniſhes the beholder, is made, we know of bones; and, to conclude, the ſkin of John **Zisca**, after his death, was employed as *a covering of a drum*, to excite the holy cruſade.

SECT. VIII.

OF PUTREFACTION;

OR

THE RESOLUTION OF ORGANIZED MATTER INTO ITS CONSTITUENT PRINCIPLES.

AMMONIAC *is compoſed of* $\begin{cases} \text{1. AZOT,} \\ \text{2. HYDROGEN.} \end{cases}$

PUTREFACTION is the great proceſs appointed by the CREATOR, for the reſolution of animal and vegetable ſubſtances into *the elements* from which they were firſt formed. By this proceſs, the oak and the bramble, the cedar and the hyſſop, fruits, whether delicious, or nutritive, or acrid, or poiſonous, the moſt beautiful of the human ſpecies, and the moſt frightful of the other tribes of animals, are all reduced to one common lot: they finally return back to their original and primeval elements.

This reſolution of bodies, when philoſophically conſidered, is equally wonderful with their formation; and is alike governed by *regular* and *invariable laws*. Every plant brings forth its own kind, and every animal its own ſpecies. Theſe live, they are nouriſhed, and ſilently haſten to decay; they paſs back to their *elementary ſtate*, and are *again employed* as the *conſtituent parts* of *other vegetables* and *other animals*. Such, with reſpect to the material part of the creation, is the amazing circle of LIFE and DEATH! A circle in which nature keeps her ſteady rounds, and moves agreeably to laws eſtabliſhed by the ALMIGHTY.

Vegetable ſubſtances, which conſiſt of HYDROGEN, OXYGEN, and CARBON, maintain for a long while their organiſed ſtructure, and putrefy with difficulty. Having paſſed through firſt the *vinous*[*], and then the *acetous fermentations*,

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[*] The firſt effect we ſee produced on vegetable ſubſtances which have loſt their VITAL PRINCIPLE, is the deſtruction of the equilibrium, or juſt union of their three conſtituent principles (*hydrogen, oxygen,* and *carbon*), by the action, or operation, of *heat* and *moiſture*. The OXYGEN unites with the CARBON, and the fermenting juice is covered on its ſurface with *carbonic acid gas*. The ſpecific gravity of the liquor is now conſiderably diminiſhed, and if expoſed to diſtillation, it affords a *light inflammable ſubſtance*, called ALKOHOL, or SPIRIT OF WINE: which, as we might reaſonably expect from the volatilization in great part of the *carbon* and *oxygen*, is almoſt entirely made up of the other vegetable principle, *hydrogen:* for if 8 ounces of SPIRIT OF WINE OR ALKOHOL be burnt in a confined apparatus containing only *oxygen gas*,

fermentations *, they at length became ſubject to the *putrefactive ferment* †, and the HYDROGEN of the vegetable eſcapes in the form of *hydrogen gas*, while the OXYGEN and CARBON evaporate in the form of *carbonic acid gas*, leaving nothing behind but a ſmall reſiduum of carbon and vegetable earth.

It is different with ſubſtances containing a portion of AZOT. The *equilibrium of parts* is ſoon deſtroyed. Hence it is that animal excrements, which contain, like other animal matters, a quantity of AZOT ‡, are added to the elements, capable of putrefaction, to form compoſts or dunghills.

The addition of AZOT not only accelerates the putrefactive proceſs, but the *azot* combining with the *hydrogen* affords a new product, which is AMMONIAC

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gas, the product will be 9 *ounces* of WATER. The ALKOHOL, having in this caſe increaſed its weight *an ounce*, muſt have attracted *ſomething*, and *this ſomething* can be *nothing elſe* but OXYGEN, the baſe of *oxygen air*, and the CALORIC of the *oxygen air* being diſengaged, is ſeen in its active form during the combuſtion.

* This *ſecond ſtage* of ſpontaneous decompoſition, as it is called, is nothing more than the *abſorption* or *imbibing* of OXYGEN from the air.

† When the ſpontaneous decompoſition is ſuffered to proceed beyond the *acetous proceſs*, then the *third ſtate*, or PUTREFACTIVE FERMENT, takes place.

‡ The putrefactive proceſs is moſt eminently perceived in *animal bodies*. Theſe either putrefy immediately; or, if the putrefaction be *preceded* by either of the other ſtages, their duration is too ſhort to be perceived.

or VOLATILE ALKALI. Monſ. Bertholet has proved, by a variety of experiments, that AMMONIAC is produced by the union of *azot* and *hydrogen*, for if the *azot* in the *animal ſubſtances* be diſengaged by the action of diluted nitrous acid, NO AMMONIAC will be produced, and in all caſes putrifying ſubſtances furniſh AMMONIAC only in proportion to the *azot* they contain.

The following experiment alſo fully proves the compoſition of AMMONIAC.

If AMMONIAC be combined, ſays Monſ. FOURCROY, with a METALLIC OXYD, the *hydrogen* of the AMMONIAC will unite with the *oxygen* of the METALLIC OXYD, and form *water*, whilſt the *metal* is revived, and the *azot*, being left free, will unite with the *caloric* and aſſume the form of a *gas* or *air**.

AMMONIAC has a peculiar penetrating odour. In the putrefaction of animal ſubſtances ſometimes AMMONIAC predominates, which is eaſily perceived by its ſharpneſs upon the eyes, and ſometimes, as in putrid herrings, the PHOSPHORATED HYDROGEN GAS is moſt abundant.

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* The beſt method of obtaining *azotic gas* for medicinal purpoſes, is, by burning a wax candle, or charcoal, in a given quantity of atmoſpheric air confined in a bell glaſs inverted over water. The oxygen is conſumed, and fixed air formed, which may be eaſily abſorbed by ſquirting into the bell, lime, or even common, water, by means of a ſyringe. Dr. THORNTON uſes this ſimple proceſs for impregnating water with fixed air.

Phosphorus is found in almoſt all animal ſubſtances, and in ſome plants which give indeed a kind of animal analyſis.

It is chiefly to **ammoniac** *(hydrogen* and *azot)* and **phosphorus** diſſolved in **hydrogen gas**, that the fœtor iſſuing from the putrefaction of animal ſubſtances depends. This vapour is highly hurtful to animal life. When accumulated, if the pick-axe of the grave-digger unfortunately ruptures the coffin, it burſts forth, and oftentimes proves fatal to the ſexton, and is ſeen to affect even perſons *at ſome diſtance* with vertigo, nauſea, and uneaſineſs*. May we not conceive, that a poiſon ſufficiently ſubtle to produce the immediate death of many, when it firſt eſcapes from the place where it is confined, may even after it is diffuſed in the air retain virulence enough to injure the delicate animal fibre? After having obſerved the conſtant dread that grave-diggers have for this poiſonous vapour, after having ſeen the cadaverous paleneſs of countenance, and other marks of the gradual action of a ſlow poiſon ſo evident in the appearance of *all men employed much in church-yards*, it is impoſſible not to believe that the air in their immediate neighbourhood muſt, in ſome meaſure, injure the health of the inhabitants *.

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* An inſtance of this happened, when the ground of the church of St. *Benoit*, at *Paris*, was dug up a few years ago; a nauſeous vapour was emitted, which, beſides its deleterious effect upon the grave-diggers, injured perſons even who lived in the vicinity. Meſſrs. **Maret** and **Navier** have given us ſeveral ſimilar occurrences.

* Mr. CAREY, in deſcribing the peſtilential *fever* which prevailed in PHILADELPHIA, and ſwept off above 4000 perſons, emphatically ſays, " Shall I be pardoned for paſſing a cenſure on thoſe, whoſe miſtaken zeal led them, during the moſt dreadful ſtages of this calamity, to crowd our churches, and aid this frightful enemy in his work of deſtruction? who, fearful leſt his prayers and adorations at home would not find acceptance before the Deity, reſorted to *churches filled with bodies*, where, with every breath, they inhaled a CONTAGIOUS AIR. To *this ſingle cauſe* I am bold in aſcribing *a large portion of the mortality*. I hope," he continues, " the awful leſſon ſome of our congregations hold forth on this ſubject, by a *mortality* out of *all proportion* to their numbers, will ſerve as a MEMENTO at all future times."

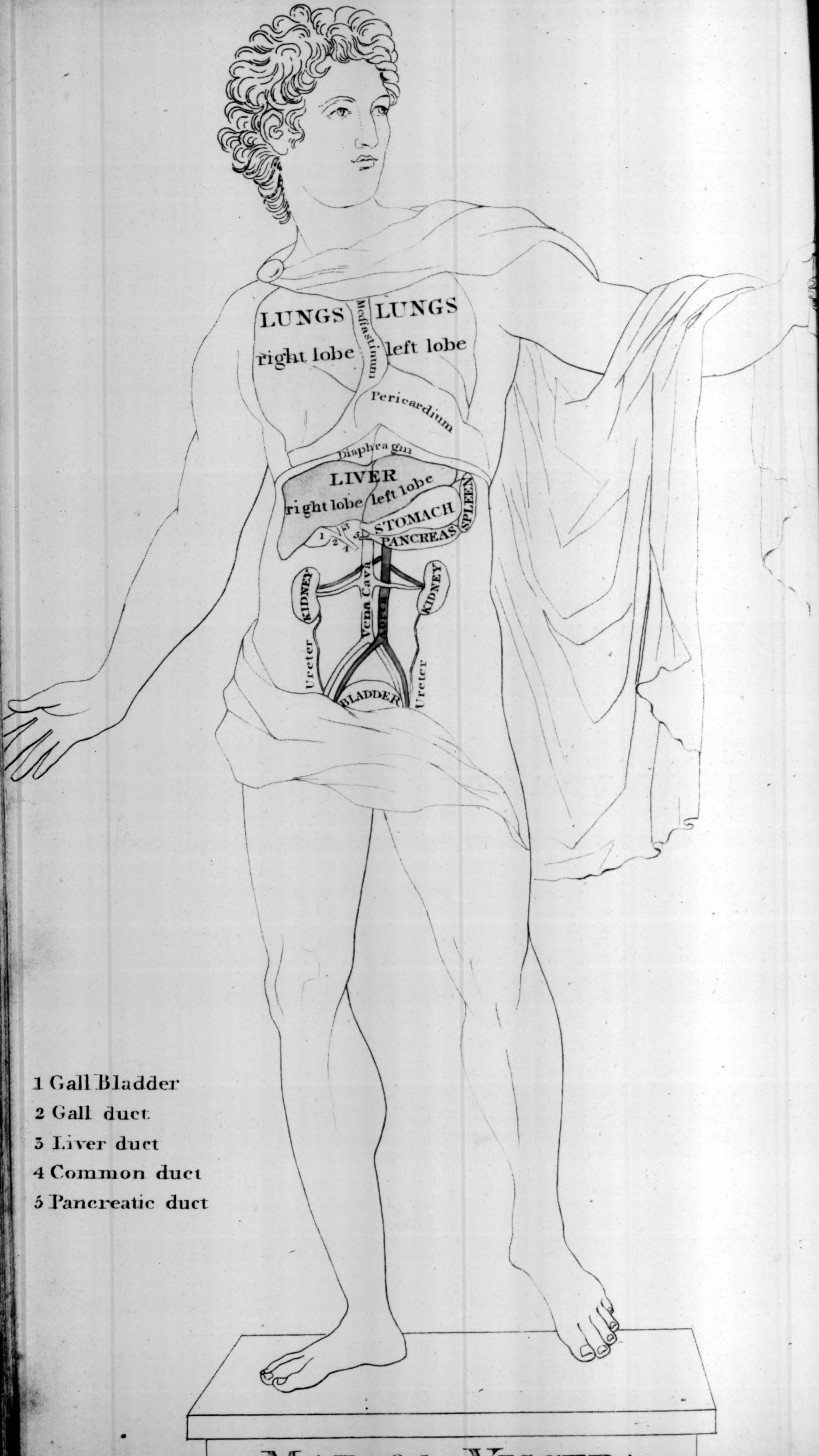
This benevolent gentleman would not ſurely wiſh to prevent perſons from aſſembling together, eſpecially in times of calamity, to pay their worſhip to THE SUPREME BEING, from whom every bleſſing that we enjoy flows, and on whom we utterly depend; but he ſhould rather caution us againſt *ſmall* churches, and the abominable practice of *burying the dead* in them, and thus converting *the temples of* GOD literally into *bone houſes.* The cuſtom which allows of burying in churches ought certainly to be ſuppreſſed. This is an abuſe which calls aloud for reformation. It is but juſt that the vanity of the individual ſhould be ſacrificed to the public ſafety. It is neceſſary, likewiſe, to prohibit burying in vaults. The grave ſhould be deep, and covered over with a clayey earth, that the exhalations, vapours, and gazes, which are developed and formed by decompoſition, ſhould not have an eaſy eſcape. At *Bath* the pariſh church is famous for a fine roof and extenſive proſpect, and ſtrangers frequently walk on the top. If, at any time, the noſtrils be applied to any of the openings, the ſtench which aſcends is ſo abominable, that the face is haſtily withdrawn. Though more diffuſed in the church, can we doubt a moment of the inſalubrity of ſuch an atmoſphere?

PART II.

THE AGENCY
OF
OXYGEN, OR VITAL, AIR
IN
THE ANIMAL BODY.

Aëra nunc igitur dicam, qui corpore toto
innumerabiliter privas mutatur in horas.
Semper enim quodcunque fluit de rebus, id omne
aëris in magnum fertur mare, qui niſi contra
corpora *retribuat* rebus recreetque fluentis,
omnia jam reſoluta forent, et in aera verſa.
Haud igitur ceſſat gigni de rebus, et *in res
recidere* aſſidue, quoniam fluere omnia conſtat.

LUCRET.



1 Gall Bladder
2 Gall duct
3 Liver duct
4 Common duct
5 Pancreatic duct

MAP of the VISCERA

INTRODUCTION.

A CONCISE VIEW OF THE WHOLE ANIMAL ECONOMY.

LET us begin with the leſs adorned, but more SOLID PARTS, which *ſupport* and *defend* the reſt.

General Obſervations reſpecting the Bones.

Firſt, we have a SYSTEM OF BONES, made in a *variety* of ſhapes,—in a *variety* of ſizes:—all *ſtrong*, that they may bear up the machine, yet *light*, that they may not weigh us down:—*hollowed* with an inward cavity, to contain the moiſtening marrow, and *perforated* with fine ducts, to admit of the nouriſhing veſſels.

They are *larger* at their extremities,—and *inſenſible*,—that they may be *joined* more firmly, and may not be *hurt* by preſſure.

The manner of their *articulation* is *truly admirable*, and remarkably various: yet *never varied* without demonſtrating ſome wiſe deſign, and anſwering ſome valuable end.

Frequently, when *two bones* are *united*,—the *one* is nicely *rounded* and capped with a ſmooth ſubſtance; the *other* is *ſcooped* into a hollow of the ſame dimenſions to receive it: and *both* are *lubricated* with an *unctuous fluid* to obviate the evil of *friction*, and to facilitate *rotation*.

Theſe are connected by LIGAMENTS,—a tough and ſtrong arrangement of fibres, which *render*, what would *otherwiſe* be an *elegant*, yet *uſeleſs aſſemblage* of *parts*, a *well compacted* and *manageable* SYSTEM.

The Feet.

The FEET compoſe the firmeſt pedeſtal, infinitely beyond all that ſtatuary can accompliſh,—capable of *altering* its *form*,—and *extending* its *ſize*,—as different circumſtances require.

The undermoſt part of the heel, and the extremity of the ſole, are ſhod with a TOUGH INSENSIBLE SUBSTANCE: a kind of *natural ſandal*, which never wears out, never wants repair; and which prevents an undue compreſſion of the veſſels by the weight of the body.

The LEGS and THIGHS are like ſtately columns, ſo *articulated*, that they are commodious for *walking*, and yet adapted for the eaſy poſture of *ſitting*.

The Legs and Thighs.

The RIBS, turned into a regular arch, are gently *moveable*, for the act of reſpiration:—they form a *ſafe lodgment* for the *lungs* and *heart*, the two moſt important organs of life.

The Ribs.

The BACK-BONE is deſigned, not only to *ſtrengthen* the body, but to *ſhield* the continuation of brain, uſually termed the SPINAL MARROW, an almoſt infinite aſſemblage of nerves!

The Back-bone.

By commodious *outlets* it tranſmits *theſe ſilver cords* to different parts of the body.

Had it been a *ſingle bone*, the *loins* muſt have been *inflexible*; to avoid which, it conſiſts of a number of *ſmall bones*, which *articulate* together, and are *ſtrengthened* by compact *ligaments*.

By this means it is capable of various *inflections*, without *injuring* the *cords of life*, or *diminiſhing* that *ſtrength*, which is ſo much required here.

This *peculiarity of ſtructure* gives the BACK-BONE the *pliancy* of an *oſier*, with the *firmneſs* of an *oak*.

Such a formation in any other of the ſolids muſt have occaſioned *great inconvenience.* Here it is *unſpeakably uſeful*, a *maſter-piece* of *creating ſkill!*

The Arms.

The ARMS are exactly *proportioned* to each other, to preſerve the *equilibrium* of the ſtructure.

Theſe being—the *guards* to *defend*,—and the *miniſters* that *ſerve* the whole body,—are fitted for *the moſt diverſified* and *extenſive operations:*—*firm* with *bone*, yet not *weighty* with *fleſh*,—and *capable of performing all uſeful motions*, they bend *inward*, and turn *outward:* they move *upward*, or *downward.* They *wheel about* in *whatever direction* we pleaſe.

The Hands.

To theſe are added HANDS, terminated by the FINGERS,—not of the *ſame length*,—nor of *equal bigneſs*,—but in *both reſpects* different, which gives *more beauty*, and *far greater uſefulneſs*.

Were they *all fleſh*, they would be *weak:*—were they *one entire bone*, they would be utterly *inflexible:*—but, conſiſting of *various little bones* and *muſcles*,—*What ſhape can they not aſſume!*

Being placed at *the end* of the arm, the *ſphere* of their action is exceedingly *enlarged.*

Their *extremities* are *an aſſemblage* of the *fineſt nerves*, *acutely ſenſible*:—which, notwithſtanding, are deſtined to almoſt inceſſant employ, and frequently among *rugged objects*.

For *this reaſon* they are overlaid with NAILS, which preſerve them from any violent injury. *Nails.*

The HAND is the original and univerſal ſceptre, which not only *repreſents*, but *aſcertains* our *dominion* over *all the elements*, and over *every creature*.

To theſe HANDS we owe thoſe *beautiful ſtatues*, this *melodious clarinet*.

By *the ſtrength* of the HAND *the talleſt firs* fall, and the *largeſt oaks* deſcend from the mountain.

Faſhioned by the HAND they become a *floating warehouſe*, and carry the *productions of art* from BRITAIN to the remoteſt corner of the univerſe.

Though we have not the *ſtrength* of the *horſe*,—*ſwiftneſs* of the *greyhound*,—or the *quick ſcent* of the *ſpaniel*,—yet, *directed* by the *underſtanding*, and *enabled* by the HAND, we can, as it were, make them all our own.

Theſe *ſhort* HANDS have found a way to *penetrate* the *bowels* of the *earth*.

Theſe *feeble* HANDS can *manage* the *wings of the wind*,—*arm* themſelves with the *violence of thunder*,—and preſs into *their ſervice* the *forcible impetuoſity of water!*

How greatly then are we indebted to our infinitely wiſe CREATOR, *for this diſtinguiſhing*, *this invaluable member!*

The Head.

Above all is the HEAD, for the reſidence of the *brain*, rounded to *receive*, and firm to *defend* it.

This is *ſcreened* from *heat*,—*defended* from *cold*,—and at the ſame time *beautified* by the HAIR:—a decoration *ſo delicate*, as no art can ſupply;—ſo *perfectly light*, as no way to encumber the wearer.

While *other animals* are *prone* in their aſpect, the attitude of *man* is *erect*, which is by far the moſt commodious for proſecution of all his extenſive deſigns. Does it not *remind* us of our *noble original*, and our *ſublime end?*

The Countenance.

Struck with the grandeur of the ſubject, we would fain ſet forth all its beauties; but our pencil, which is too faint, cannot correſpond with the vivacity of our conceptions. How indeed can any one deſcribe with due energy—the admirable *proportions:—theſe features*, full of force and dignity, expreſſing to all beholders the emotions and paſſions as they ariſe in the heart;—this open and elevated *brow*:—theſe lively and piercing *eyes*, eloquent interpreters of the ſentiments of the ſoul;—this *mouth*, the ſeat of ſmiles; —theſe *ears*, whoſe delicacy catches even the ſofteſt whiſpers!

Obſervations on other Parts of the Body.

IF you take a ſtill further ſurvey of THIS BEAUTIFUL EDIFICE;—the *prodigious number* of its parts,—their *ſurpriſing diverſity*,—*admirable conſtruction*,—*wonderful harmony*,—and *infinite art*, diſplayed in the diſtribution of them,—it will throw us into ſuch an *ecſtaſy*, as we ſhall no ſooner recover from, than *complain* of our want of *ſufficient inclination* and *ability* to *admire* ſuch MARVELLOUS EXCELLENCY.

The Arteries.

Here are ARTERIES, the *rivers* of our little world, that, ſtriking out as they go into *numberleſs ſmall canals*, viſit *every ſtreet*, yea *every apartment*, in *the vital city*.

They are not, like ſeveral of the veins, *near the ſurface*, but placed at a *ſufficient depth*, and thereby are more *ſecure* from *external injuries*.

The ARTERIES alſo *communicate* by *collateral branches* with *each other*; ſo that if any thing *block up* or *ſtraiten* the *direct paſſage*, the *current*, by *diverting* to *this new channel*, eludes the impediment, flows on, and ſoon regains its wonted courſe.

The Pulſe. The blood thrown from the heart *dilates* inſtantly the ARTERIES, whoſe fibres by their *irritability*, or *elaſtic power*, *react* on the blood: by which means as they propel it onward, they *vibrate* againſt the finger, and much aſſiſt the phyſician in the diſcovery and cure of diſeaſes.

The Veins. *The extreme branches* of ARTERIES terminate in VEINS, which may be conſidered as uniting again into larger branches; then again into branches ſtill larger, and ſo on continually, till at laſt they form *one large pipe* or *trunk*, which *reconveys* the blood to the heart.

The *Diſtinction* betwixt a *Vein* and an *Artery*. The ARTERIES are compoſed of ſeveral principal membranes placed on each other. One of theſe is highly elaſtic.

The VEINS, not being deſigned to exerciſe the ſame function as the arteries, *want this elaſtic coat*, and the texture of the reſt is conſiderably *ſlighter*; ſuch an *exact œconomiſt* is nature amidſt *all her liberality!*

The Valves.

At the root of the ARTERIES, and in the inner part of the VEINS, are placed little SLUICES or VALVES, which by ſinking, and riſing again, *open*, and *ſhut* the canal.

Theſe are found only where the blood is conſtrained to *climb*, for where *the aſcent ceaſes*, they *ceaſe alſo*.

The Heart.

In the centre of the breaſt, between two *ſpungy maſſes*, known by the name of THE LUNGS, is depoſited a fleſhy and hollow pyramid, called the HEART. This pyramid has its apex turned towards the left ſide, and is the MAIN SPRING of the animated machine.

The Lungs.

The ramifications of the BRONCHIA, or WIND-PIPE, which are diſperſed throughout the LUNGS, carry thither the *vivifying air*, which, by acting on *their ſpungy maſs*, opens, dilates, and extends them, and by that means facilitates the courſe of the blood.

General Obſervations on the Organs performing the Circulation of the Blood.

Such indeed are the admirable organs deſtined for *the circulation of the blood.* But how greatly does this imperfect ſketch fall ſhort of the reality! How incapable are theſe outlines of expreſſing the beauties of this noble ſubject!

There is, in the conſideration of the organs performing the circulation of the blood, an air of *grandeur* that ſeizes forcibly on the mind, and penetrates it with the higheſt admiration.

Far *leſs magnificent* in its plans, *leſs ſkilful* in the execution of them, HYDRAULICS offer us but *faint images* of this miracle, in thoſe machines, by means of which water is diſtributed into every quarter of a great city.

The works of the CREATOR muſt be compared to the *emanations* of the ſame INFINITE MIND. Ever like himſelf, HE has impreſſed on all *his* productions a character of nobleneſs and excellence, which demonſtrate their *divine original.*

But what are thoſe excellent diſcoveries *philoſophy* has made, compared with the beauties that are ſtill *concealed* from our view! The gloom of night veils many important truths concerning the animal body, and you are deſirous of ſeeing it chaſed away. Will the dawn of that day ere long gild the horizon of the learned world? or is the time of its breaking forth upon us yet afar off?

The Glands.

The GLANDS are an aſſemblage of *tortuous veſſels*, *complicated* with *ſeeming confuſion*, yet *perfectly regular*.

We cannot as yet *penetrate* into the *myſtery* of SECRETION; all that we know is, that thoſe fluids ſaid to be *ſecerned* are not *abſolutely contained within the blood*, any more than the *peach*, *nectarine*, or *other fruits*, are principles *filtered* from the earth, and water, which nouriſh the tree.

Nevertheleſs as the *ſeven notes* of muſic *differently combined*, and the *twenty-four letters*, form the whole of *harmony*, and *language*, ſo may *all theſe fluids* ariſe from the *change* of *combination* of *primitive parts*, by a machinery that no chemiſt may ever be able perfectly to imitate.

But if we cannot unlock the whole of theſe ſublime operations, we ſhall at leaſt ſee *enough* to excite our admiration; and, from *the ſketch* I have already given of SOME LATE CHEMICAL DISCOVERIES, and the view I am about to take of THE

AGENCY OF OXYGEN AIR IN THE ANIMAL BODY, we may yet entertain ſome feeble hope, that a glimmering of light will, in this age of inveſtigation, be darted on theſe ſubtle and hitherto impenetrable ſubjects.

The Nerves.

We have NERVES, which ſhoot out their fibres from the brain, and when remote from their ſource are *ſurpriſingly minute*,—which *ſet the muſcles to work* at the command of the will,—and diffuſe *ſenſation* throughout the body,—and upon any impreſſion from without give *all needful intelligence* to the ſoul.

The Membranes.

We have MEMBRANES, thin and flexible coverings,—to *enwrap* the fleſhy parts,—to *connect* ſome,—and form a *ſeparation* between others.

The Muſcles.

We have MUSCLES, compoſed of the *fineſt fibrils*, yet endued with *incredible ſtrength*;—faſhioned after a *variety* of patterns, but all in the higheſt taſte for elegance and uſe. Theſe execute their functions as quick as *lightning*.—Were we to remove mountains, we could not be more aſtoniſhed, than that this arm, theſe fingers ſhould obey the order of the will.

To turn the ſcrew, or work the lever, is laborious and weariſome. But we work the vertebræ of the neck, with all their appendant parts; we advance the leg with the whole incumbent body; we riſe, we ſpring from the ground; and though ſo great a weight is raiſed, we meet with no difficulty or fatigue.

That all this ſhould be effected without any toil, by *a bare act of the will*, is very ſurpriſing. But *that it ſhould be done*, even *while* we are *entirely ignorant* of the *manner in which it is performed*, is moſt aſtoniſhing!

Who can play a ſingle tune upon the ſpinnet, without learning the difference of the keys? Yet *the mind* touches *every ſpring* of the human machine with the moſt maſterly ſkill, though ſhe knows nothing at all of the nature of her inſtrument, or the proceſs of her operation.

More than two hundred reins are put into her hands; yet ſhe manages all, conducts all, without the leaſt perplexity or irregularity. Rather with a promptitude, a conſiſtency, and ſpeed, that nothing elſe can equal!

The Fat.

We have FAT, an *unctuous fluid* contained in *veſicles*, which have the appearance, if viewed through a microſcope, of a cluſter of grapes.

This *flanks* and *fortifies* our muſcles like a ſtrong baſtion, *ſupports* and *warms* them like a ſoft pillow.—In other places they *fill up* the vacuities, and *ſmooth* the irregularities of the fleſh.—*Inwardly*, they ſupple the machine for motion; *outwardly*, they render it ſmooth and graceful.

The Skin.

The SKIN is a curious ſurtout which covers the whole, formed of the moſt delicate net-work, whoſe meſhes are minute, and whoſe threads are multiplied, even to a prodigy; the meſhes are ſo minute, that nothing paſſes them, which is diſcernible by the eye; though they *diſcharge*, every moment, myriads and myriads of ſuperfluous incumbrances*. Theſe threads are ſo multiplied, that neither the point of the ſmalleſt needle, nor the infinitely finer lance of a gnat, can pierce any part, without drawing blood, and cauſing an uneaſy ſenſation. Conſequently, without wounding, by ſo ſmall a puncture, both a *nerve* and a *vein!*

The Uſes of the other Parts of the Body.

But a courſe of inceſſant action muſt exhauſt the ſolids, and waſte the fluids, and unleſs both be properly *recruited*, the machine would be deſtroyed.

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* The perſpirable fluid is 2 parts FIXED AIR, and 1 part AZOTIC AIR; and 3dly, WATER impregnated with different *ſaline matters.*

For *this reaſon* our body is furniſhed with the ORGANS, and endued with the *power* of NUTRITION.

The Teeth. We have TEETH, teſts of heat and cold, the *foremoſt*, thin and ſharp, to bite aſunder the food;—the *ſide teeth* for the purpoſe of tearing;—and the *hindermoſt*, broad and ſtrong, indented with ſmall cavities, the better to grind into pieces what is tranſmitted to them.

Were the TEETH, like other bones, covered with the perioſteum, chewing would give much pain. Were they quite naked, they would ſoon decay and periſh. To *guard* againſt *both*, they are overlaid with a neat ENAMEL, harder than the bone itſelf, which gives no pain in chewing, and yet ſecures them from various injuries.

The Lips. The LIPS prevent the food from ſlipping out of the mouth, and, aſſiſted by the tongue, return it to the grinders.

The Cheeks. While they do this in concert with the CHEEKS, they ſqueeze a *thin liquor* from the adjacent glands. *This moiſtens* the food, and prepares it for digeſtion.

The Salivary Glands. When the mouth is inactive *theſe glands* are nearly cloſed; but when we ſpeak or eat, their moiſture being then neceſſary, is expreſſed as needs require.

But

The Gullet.

But *the food* could not *deſcend* merely by its *own weight*, through a narrow and clammy paſſage into the ſtomach.

Therefore to effect this, *fibres* both *ſtraight* and *circular* are provided. The *former* enlarge the cavity, and give an eaſy admittance. The *latter*, cloſing behind the deſcending aliment, preſs it downward.

The Wind-pipe.

But before the food enters the gullet, it muſt of neceſſity *paſs over* the *orifice* of the WIND-PIPE: whence it is in danger of falling upon the lungs, which might occaſion inſtant ſuffocation.

To *obviate this*, a MOVEABLE LID is placed, which when the ſmalleſt particle advances, is *pulled down* and *ſhut cloſe*, but as ſoon as it is ſwallowed, is again let looſe and ſtands open.

Thus the important paſs is always *made ſure* againſt any noxious approaches; yet *left free* for the admiſſion of air, and for reſpiration.

The Stomach.

The food deſcending into the STOMACH, is not yet ready for the bowels. Therefore that great receiver is ſtrong to bear, and fitted to detain it, till it is properly wrought into the ſmootheſt pulp by the ſolvent power of the GASTRIC JUICE, a fluid ſecreted in the ſtomach itſelf.

From

Of the Inteſtinal Canal.

From hence it is *diſcharged* by a gentle force, and *paſſes gradually* into the inteſtines.

The Pancreas and Gall-bladder.

Near the entrance of this canal are THE DUCTS of the PANCREAS and GALL-BLADDER, which being *ſtimulated* by the chyle*, occaſions their reſpective glands to pour forth their ſalutary juices.

The Spleen.

The PANCREAS is *connected* with the SPLEEN, which, as the ſtomach gets filled, becomes preſſed thereby, and in conſequence pours into *this gland* a greater quantity of blood, to be changed into *the pancreatic juice.*

The Liver.

The GALL-BLADDER is *attached* to the LIVER, and is the *reſervoir* to detain the bile, which *purges* the inteſtines, and *blends* the *oil* and *aqueous parts* into *one homogeneous maſs.*

It is furniſhed with a VALVE of a very peculiar nature, namely of a *ſpiral form*; through which the deterſive liquid can only gently ooze. Admirable conſtructions, which give the needful ſupply, as occaſion may require, and no more!

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[*] A term uſed to expreſs the aliment when diſſolved in the ſtomach.

The nutriment then purſues its way through the mazes of THE INTESTINES.

The Plaits of the Inteſtines.

Had theſe been ſtrait or ſhort, the food could not have reſigned a ſufficient quantity of its nouriſhing particles: therefore it is artfully *convolved*, and filled with numberleſs *folds* or *plaits*, and of *great length*.

The Villous Coat of the Inteſtines.

Along the ſides of this winding paſſage, countleſs multitudes of MINUTE VESSELS protrude themſelves, and abſorb the nutritious juices.

The Mucous Glands of the Inteſtines.

As the aliment proceeds, it is more and more drained of its nutritious juices.—GLANDS are therefore poſted in proper places to diſcharge a lubricating fluid. Theſe are ſmaller, or fewer, in and near the ſtomach, becauſe there the aliment is moiſt enough: whereas in the bowels, remote from the ſtomach, they are either multiplied or enlarged.

The Lacteals.

The *chyle* drawn off by the LACTEALS is carried through millions of tubes, whoſe perforation is too fine even for the microſcope to diſcover. To this it is owing that nothing enters the blood, but what is capable of paſſing through the *fineſt* veſſels.

It

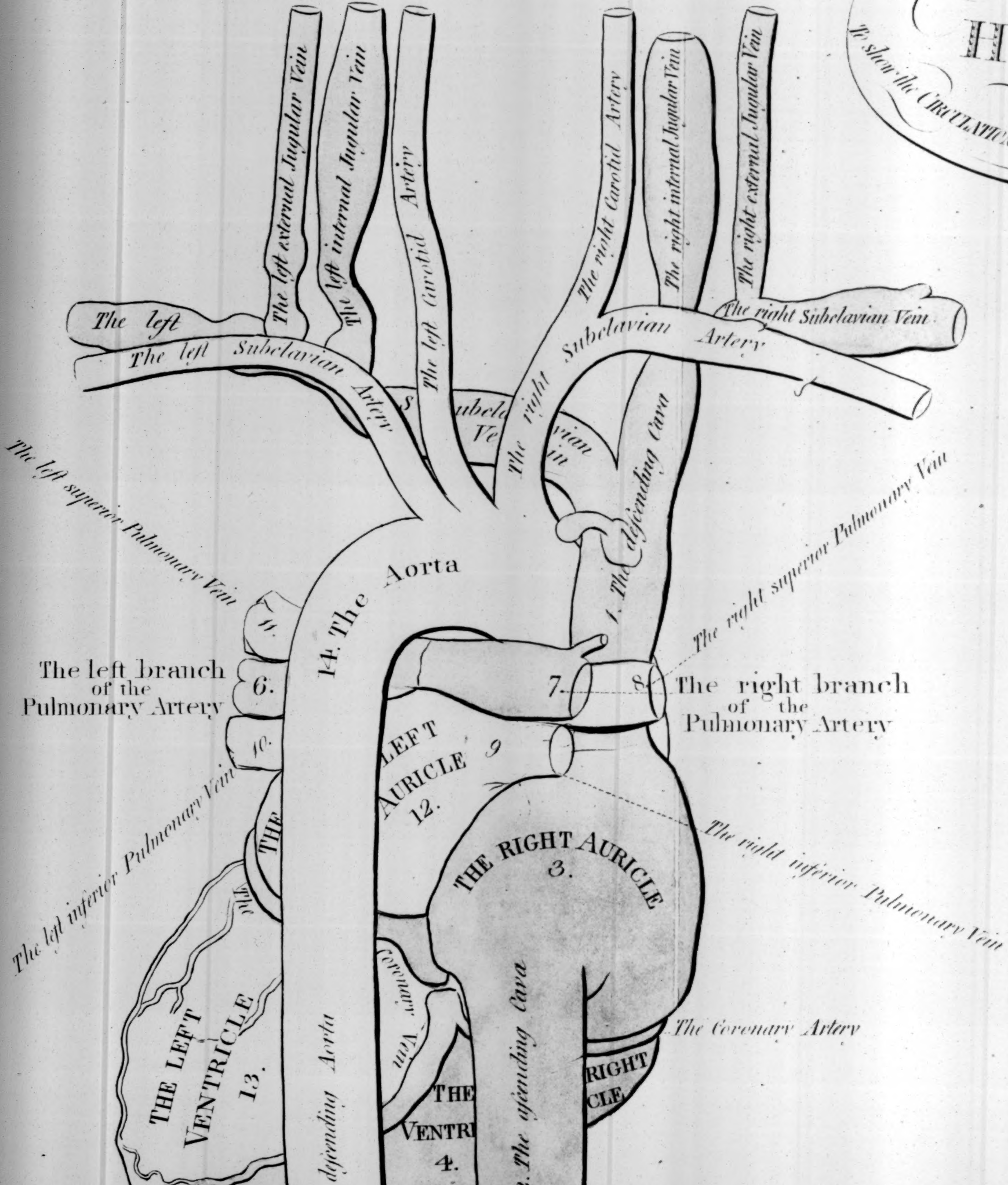
THE BACK VIEW OF THE HEART

A M

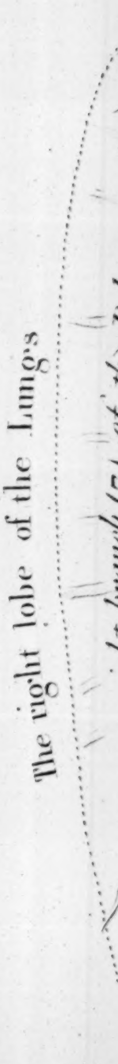
of th

HEA

To shew the CIRCULATION, & the effe



The left external Jugular Vein
The left internal Jugular Vein
The left Carotid Artery
The right Carotid Artery
The right internal Jugular Vein
The right external Jugular Vein
The left
The left Subclavian Artery
The right Subclavian Vein
The right Subclavian Artery
8 Subclavian Vein
The right Subclavian Vein
The descending Cava
The left superior Pulmonary Vein
The right superior Pulmonary Vein
1. The descending Cava
14. The Aorta
11.
The left branch of the Pulmonary Artery
6.
7.
8.
The right branch of the Pulmonary Artery
10.
9
THE LEFT AURICLE 12.
The left inferior Pulmonary Vein
The right inferior Pulmonary Vein
THE RIGHT AURICLE 3.
The Coronary Artery
Coronary Vein
THE LEFT VENTRICLE 13.
The descending Aorta
THE RIGHT VENTRICLE 4.
2. The ascending Cava



Drawn by W. Creswell

Published as the act Dire

Map
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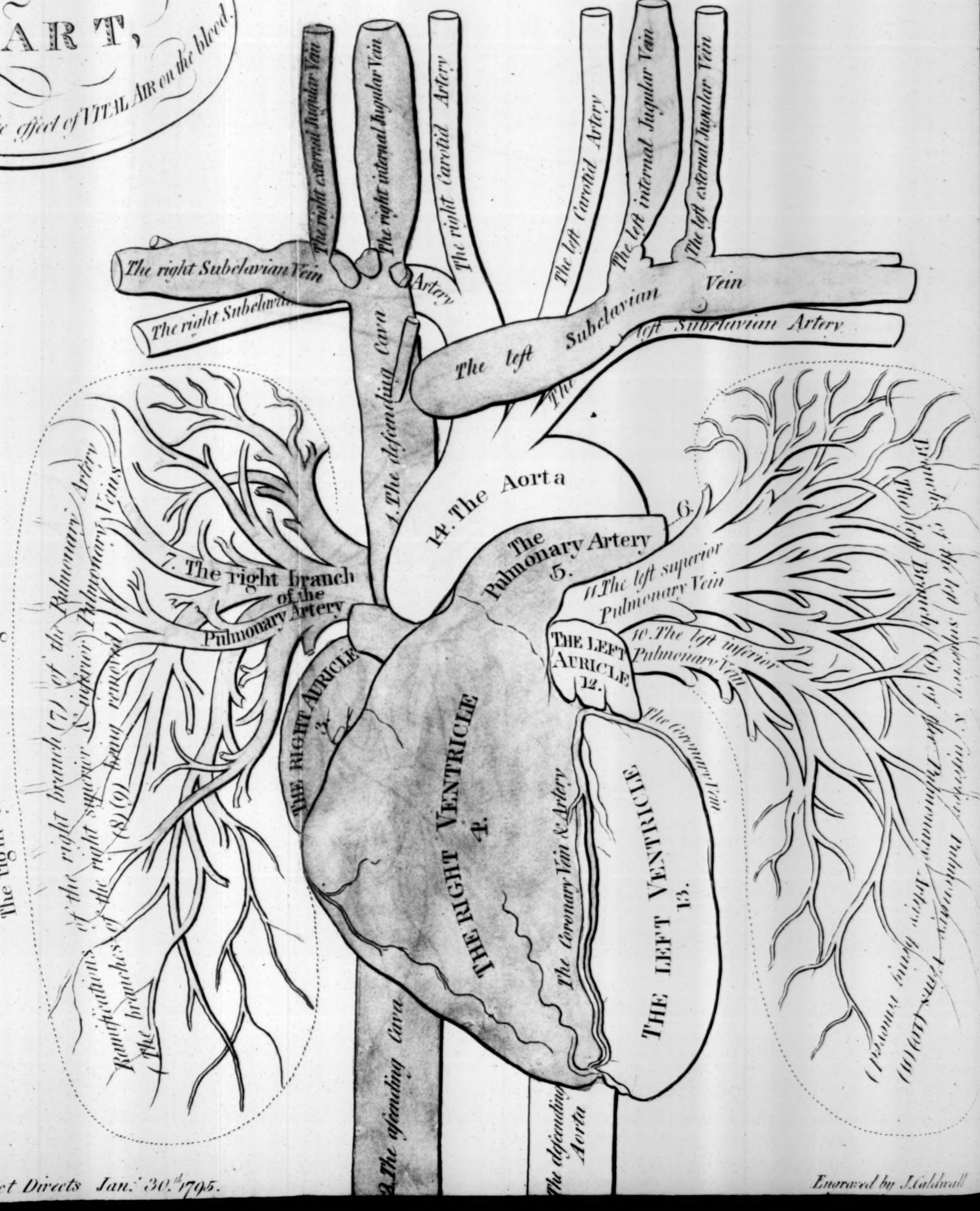
ART,
e effect of VITAL AIR on the blood.

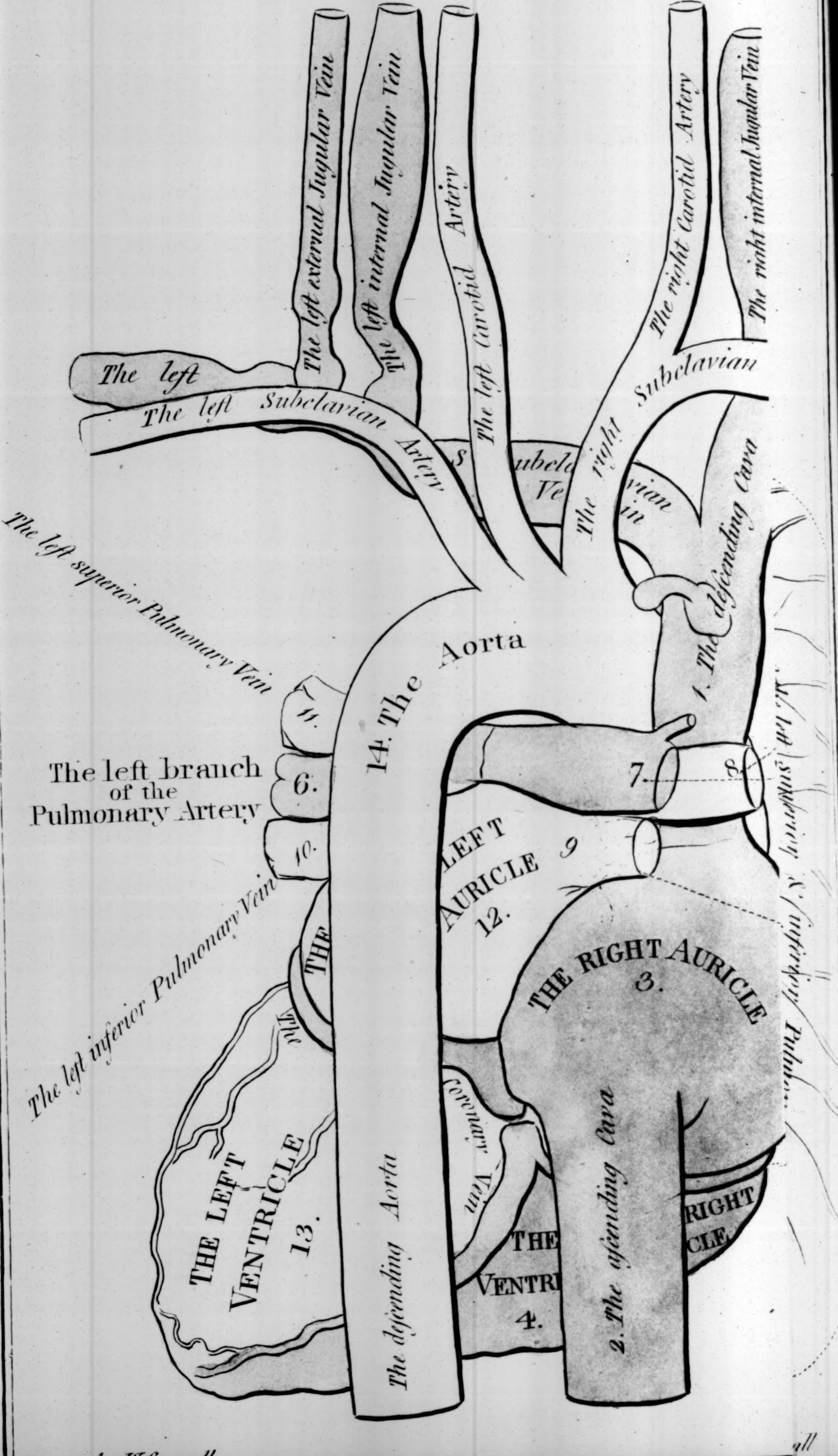
THE FRONT VIEW OF THE HEART


The right external Jugular Vein
The right internal Jugular Vein
The right Carotid Artery
The left Carotid Artery
The left internal Jugular Vein
The left external Jugular Vein
The right Subclavian Vein
The right Subclavian
Artery
The left Subclavian Vein
left Subclavian Artery
The
1. The descending Cava
14. The Aorta
6.
The Pulmonary Artery 5.
7. The right branch of the Pulmonary Artery
7
11. The left superior Pulmonary Vein
10. The left inferior Pulmonary Vein
THE LEFT AURICLE 12.
THE RIGHT AURICLE 3.
THE RIGHT VENTRICLE 4.
THE LEFT VENTRICLE 13.
The Coronary Vein & Artery
The Coronary Vein
2. The ascending Cava
The descending Aorta
Ramifications of the right branch (7) of the Pulmonary Artery
the branches of the right superior & inferior Pulmonary Veins (8)(9) being removed
The left Branch (6) of the Pulmonary Artery
Branches of the left superior & inferior pulmonary Veins (10)(11) being removed
The righ

et Directs Jan.y 30th 1795.

Engraved by J. Caldwall

THE BACK VIEW OF THE HEA



Drawn by W. Creswell

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It is then lodged in ſeveral commodious cells (the GLANDS of the MESENTERY) and there mixed with a thin diluting *lymph*, which makes it more apt to flow.

The Meſenteric Glands.

Here it is conveyed to THE COMMON RECEPTACLE, and mounts through a PERPENDICULAR TUBE to be poured into the LEFT SUBCLAVIAN VEIN*. *There* it *mixes* with the blood, and *loſes* the *name* of *chyle.*

Receptaculum Chili.
The Thoracic Duct.
The left Subclavian Vein.

From THIS VEIN the *new blood* paſſes into the UPPER BRANCH of the PRINCIPAL TRUNK of VEINS†, which carries it towards the heart.

The Vena Cava Superior.

It then paſſes into the RIGHT AURICLE ‡ of the heart, which *opens* at its approach, and, by *cloſing* immediately, forces it into the RIGHT VENTRICLE ||, which is *dilated* to receive it.

The right Auricle of the Heart.
The right Ventricle.

The VENTRICLE inſtantly *contracts* itſelf (the *valve*, with which it is furniſhed, raiſing itſelf to oppoſe the reflux into the auricle); and the blood is compelled to paſs into THE GREAT ARTERY*, which is appointed to carry it to the lungs.

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* Vide the engravings of the heart.

† Vide figure (1). ‡ Vide figure (3). || Vide figure (4).

The Pulmonary Artery.

The PULMONARY ARTERY, which is ſubdivided into *two trunks*†, which paſs to the right and left lobes compoſing the LUNGS (its *valve* preventing the reflux into the heart), by contracting, drives the blood into every part of that organ.

The Air Cells of the Lungs.

In the *ſpungy cells* of this amazing laboratory, the blood imbibes the *oxygen portion* of the external air, and aſſumes, in conſequence, *a more brilliant colour* ‡.

The left Auricle.
The 4 Pulmonary Veins.

Thus improved, it *enters* THE LEFT AURICLE of the heart || by *the four* PULMONARY VEINS §, and, in *proportion* to the *oxygen air* contained within the blood, the LEFT AURICLE ⸸

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* Vide figure (5), plate 2.

† Vide figure (6), (7), in plate 2. The right pulmonary branch is removed.

‡ This is proved in Vol. I. Sect. IV.

|| Vide figure (12).

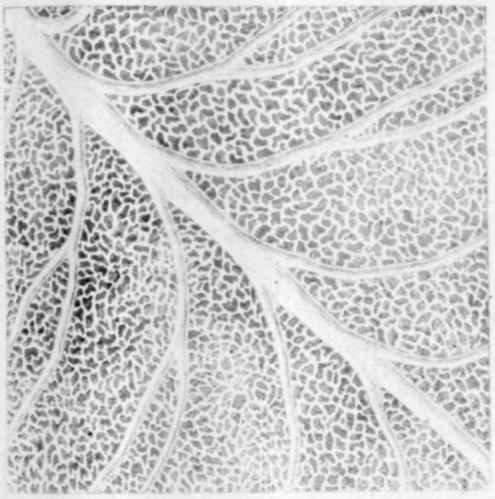
§ Vide figures (8), (9), (10), and (11). The two right pulmonary veins are repreſented in plate 2, the two left being removed.

⸸ Vide figure (12).

of

THREE SMALL PORTIONS OF THE LUNGS.

The air-cells of the Lungs;
FIG. 1.



These cells magnified.
FIG. 2.

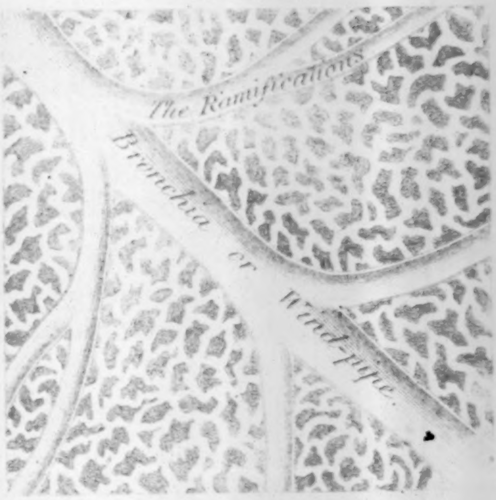


FIG. 3.

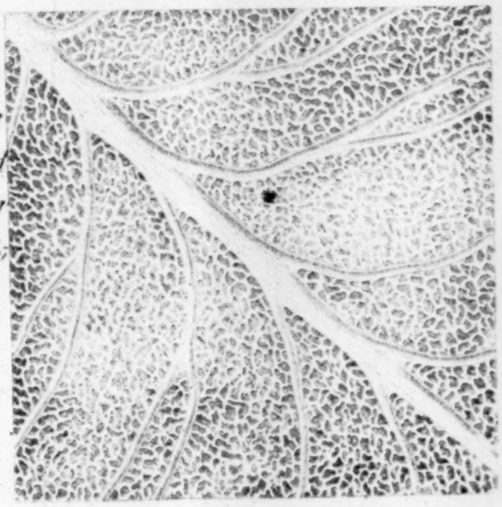
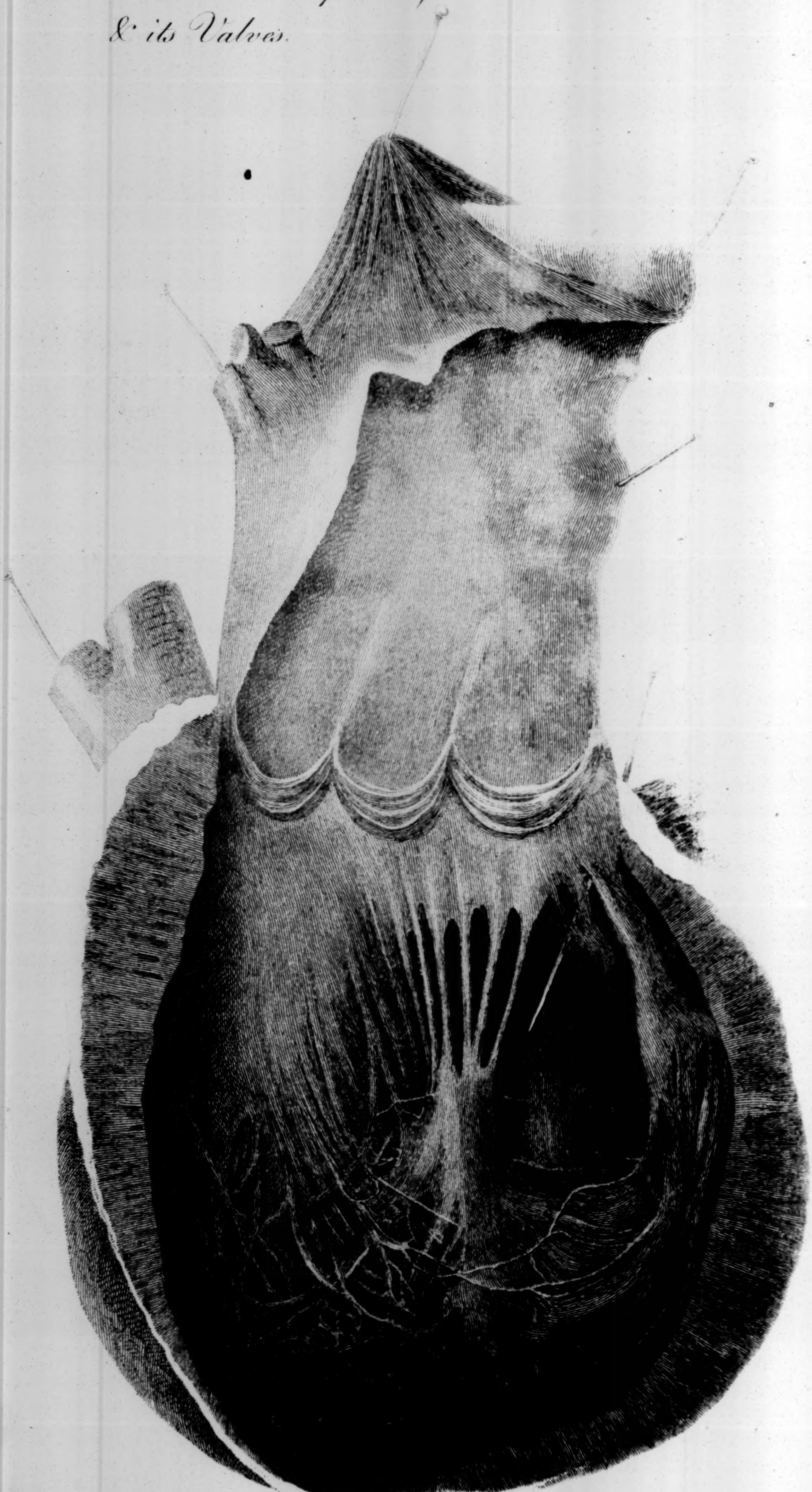


FIG. 1. 2. Shew the air-cells of the Lungs at the moment of Inspiration; when the blood in the minute veſsels covering air-cells, has Imbibed the VITAL; AIR, and thrown off CARBON & HYDROGEN.

FIG. 3. Shews the air-cells a few moments after Expiration, when a new & dark column of blood pervades the air-cells, replete with CARBON & HYDROGEN, and devoid of VITAL AIR.

Interior view of the Left Ventricle, with the Aorta & its Valves.



of the heart, obedient to the ſtimulus, contracts, and forces it into THE LEFT VENTRICLE *.

The left Ventricle.

This LATTER, by contracting itſelf, puſhes the blood into the AORTA †, which, by continually dividing and ſubdividing itſelf, diſtributes its balſamic liquor to all the parts of the body, in order to promote their *ſupport* or *growth*,—occaſion *different ſecretions*,—and diſtribute *the animal heat* ‡.

The Aorta.

By this aſtoniſhing mechaniſm, and dependence on the vital principle in the air, the powerful energy of the heart, ſeconded by that of the arteries, tranſmits the blood to the moſt remote parts of the body, notwithſtanding the reſiſtance which gravity, friction, and many other circumſtances make to it in its courſe.

The *large muſcles* of the arm or of the thigh are ſoon wearied: a day's labour, or a day's journey, exhauſts their ſtrength. But *the heart* toils whole weeks, whole months, nay years, unwearied: is equally a ſtranger to intermiſſion and fatigue.

The HEART receiving the *diſtending* and *ſtimu-*

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* Vide figure (13) in the plate.

† Vide figure (14).

‡ Vide ſect. vii. page 81.

lating power of the BLOOD, contracts on it, and in *one minute*, ſuch is its amazing force, it propels, ſays Baron HALLER, fifty-one *pounds of blood* through tubes of different dimenſions; which if meaſured out, would extend to beyond 149 feet. In a healthy perſon it contracts not much leſs than 5000 *times* in an *hour*, perpetually in the ſame order, and never with fatigue.

The PULSE ariſes from the *dilatation* and *contraction* of the ARTERIES, which in ſome meaſure correſpond with *thoſe* of the HEART.

Impelled by the AORTA (for its *valve* prevents the reflux into the heart) part of the blood ſhoots upwards to the head; part rolls through the whole body. But how ſhall a ſtream divided into myriads of channels be *brought back* to its ſource?

For *this purpoſe* the allwiſe CREATOR has connected the *extremities* of all the ARTERIES with the *beginning* of the VEINS; ſo that the *ſame force*, which darts the blood through the *former*, helps to drive it through the *latter*.

The Vena Cava Superior and Inferior.

The blood entering into the right auricle by the *two oppoſite currents* of the VENA CAVA SUPERIOR

RIOR and INFERIOR*, that the ſtreams may not claſh, a FIBROUS EXCRESCENCE interpoſes, which, like a projecting pier, breaks the ſtroke of each, and throws both into their *proper receptacle* †.

Thus is the blood *re-conducted* to the great ciſtern, and thus played off afreſh, firſt THROUGH THE LUNGS, and then THROUGH THE BODY.

Of the five Senſes.

But farther, The great CREATOR has made us an *invaluable preſent* of the SENSES, to be the *inlets* of *innumerable pleaſures*, and the *means* of the *moſt invaluable advantages*.

The Eye.

The EYE, in its *elevated ſtation*, commands the moſt enlarged proſpects.

Conſiſting only of *gelatinous fluids*, encloſed within coats, it ſhews us all the graces and glories of nature.

How wonderful, that an image of the hugeſt mountains and the wideſt landſcapes, ſhould enter the ſmall PUPIL! that the rays of light ſhould paint on the OPTIC NERVE, paint in an inſtant of time, paint in their trueſt colours and exacteſt lineaments, every ſpecies of external objects!

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* Vide figures (1) (2) in the plate.

† Namely, the right auricle.

The EYE is ſo tender, that the ſlighteſt touch might injure the delicate frame.

It is *guarded, therefore,* with *peculiar care,* entrenched deep, and barricadoed round with bones.

As the ſmalleſt fly might incommode its poliſhed ſurface, it is *farther protected* by two ſubſtantial

The Eyelids.

CURTAINS.

In ſleep, when there is no occaſion for the ſenſe, but a neceſſity to guard the organ, the curtains *cloſe* of their own accord.

At other times, if danger threaten, they *fly together* as quick as thought.

They are lined with an extremly fine membrane, moiſt with its own dew.

The Eyelaſh.

Its BRISTLY PALISADES ward off the ſweat of the brow, and moderate the too ſtrong impreſſions of the light.

As in our waking hours we have almoſt inceſſant need for theſe little orbs, they run upon the fineſt

The Muſcles of the Eye.

CASTORS, rolling every way with the utmoſt eaſe: which circumſtance, added to the inflexibility of the neck, renders our two eyes as uſeful as a thouſand.

The Ear.

The EAR conſiſts of an *outward porch* and an *inner room.*

The PORCH, ſomewhat *prominent* from the head, is of a cartilaginous ſubſtance, and wrought into *ſinuous cavities.*

Theſe, like *circling hills*, collect the wandering undulations of the air, and tranſmit them with a vigorous impulſe to the finely ſtretched membrane of the DRUM.

This is expanded upon a circle of *bones*, over a poliſhed reverberating cavity. It is furniſhed with BRACES that *ſtrain* or *relax*, as *the ſound* is *faint* or *ſtrong*.

The HAMMER and the ANVIL, the winding LABYRINTH and the ſounding GALLERIES, *theſe* and *other ſpecies* of *mechaniſm*, all inſtrumental to hearing, are inexpreſſibly curious.

Amazingly acute muſt be the AUDITORY NERVES, ſince they anſwer the ſmalleſt tremors of the atmoſphere, and diſtinguiſh their moſt ſubtle variations, even when combined.

Theſe cords, turned by an Almighty hand, and ſpread through the echoing chambers, receive all the impreſſions of ſound, and propagate them to the brain.

Theſe give the exiſtence to the charms of muſic, and ſtill nobler charms of ſpeech.

The EYE is uſeleſs amidſt the gloom of night; but the EAR hears through the darkeſt medium.

The EYE is on duty only in our waking hours; but the EAR is always acceſſible.

As there are concuſſions of the air, which are diſcernible only by the inſtruments of HEARING, ſo there are *odoriferous particles* wafted in the air, which are perceivable only by the SMELL.

The Smell.

The NOSTRILS are *wide* at the bottom, that more effluvia may enter;—*narrow* at the top, that when entered they may act more ſtrongly.

The ſtreams that exhale from fragrant bodies, are *ſine* beyond imagination.

Microſcopes that ſhew thouſands of animals in a drop of water, cannot bring one of theſe to our ſight. Yet ſo exquiſite are the OLFACTORY NERVES, ſince they arreſt the vaniſhing fugitives. They imbibe all the roaming perfumes of the ſpring, and make us banquet even on the *inviſible dainties* of nature.

Another capacity for pleaſure our bountiful CRE-

ATOR has beſtowed, by granting us the power of TASTE.

Taſte.

This is circumſtanced in a manner ſo benign and wiſe, as to be a ſtanding plea for *temperance*, which ſets the fineſt edge on the taſte, and adds the moſt poignant reliſh to its enjoyments.

To all theſe, as a moſt neceſſary ſupplement, is added the ſenſe of FEELING.

Touch.

We ſee, even from this imperfect ſurvey, that man is a very *complex machine*.

Two peculiar diſtinguiſhing excellencies in the Animal Machine.

In it there is a *peculiarity* which claims particular notice,—a *power* which defies all human ingenuity and imitation, and diſtinguiſhes the natural from any artificial machine.

1. Self Reſtoration.

As our bodies are compoſed of flexible materials, whereby they are liable to receive injuries by too rude a ſhock from harder bodies; — and as the humours are alſo ſubject to receive alterations from changes of weather, irregularities in diet, and other accidents, it was needful, that the body, beſide the power neceſſary for its performing all the functions requiſite in a healthy ſtate, ſhould be provided alſo with *other powers*, whereby the hurts, and deviations from a healthy condition, might be amended and reſtored.

Were there not *ſuch a power* in the body, we could ſcarce arrive at full age in any other than a disfigured condition, and the loſs of the due action of many parts. But our CREATOR has kindly provided, that the body, upon any wound received, ſhould ſupply *a cement*, whereby the divided parts are again united, or throw out *granulations*, and the breach is healed up. Thus a *broken bone* is made firm again by a callus; a *dead part* is ſeparated and thrown off; *noxious juices* are driven out by ſome of the emunctories; a *redundancy* is removed by ſome ſpontaneous diſcharge; a *bleeding* naturally ſtops of itſelf; and *a great loſs of blood* from any cauſe, is, in ſome meaſure, compenſated by a contracting power in the vaſcular ſyſtem, which accommodates the capacity of the veſſels to the quantity contained. Thus *the ſtomach* gives information when the ſupplies have been expended; repreſents with great exactneſs the quantity and the quality of what is wanted in the preſent ſtate of the machine; and, in proportion as ſhe meets with neglect, riſes in her demand, urges her petition with a louder voice, and with more forcible arguments; and for its protection, the animal body is made capable of reſiſting heat and cold in a very wonderful manner, and preſerves an *equal temperature* * in a burning and in a freezing atmoſphere.

There is a ſtill farther excellence or ſuperiority in the natural machine, yet more aſtoniſhing, more beyond all human comprehenſion, namely, a power to *perpetuate*, as well as to *preſerve* itſelf.

2. The Continuation of the Species.

A dead ſtatue, a painted ſhadow on a canvas, or, perhaps, a little brazen clock-work, is the ſupreme pride of the art of man, his higheſt excellence and boaſt.

On the other hand, how glorious and ſkilful an artificer would he be called, could he but make two of theſe pieces of clock-work, and ſo contrive the hidden ſprings and motions within them, that they ſhould perpetuate their kind, and thus continue the ſame ſort of clocks in more than a thouſand ſucceſſions down to the preſent day.

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* Vide ſect. x. page 96.

Such is the workmanſhip of God! *Such* the amazing power of his will! *Such* the long reach of his foreſight, who has long ago guarded againſt all poſſible deficiencies; who has provided energy in nature ſufficient to repleniſh the world with plants and animals to the end of time, by the wondrous contrivance of his creation, and the laws he then ordained.

Not all the united powers of human nature, nor a council of the niceſt artificers, with all their enginry and ſkill, can even form a ſimple gooſe-quill or a tulip. *Yet man can produce a man.* Admirable effect, yet artleſs cauſe! A poor, limited, inferior agent! The plant and the brute in this matter are *his* rivals and *his* equals too.

The human parent and the parent bird form their own images with equal ſkill, but are confined by a kind of divine patent each to his own work. So the iron ſeal transfers its own figure to the wax with as much exactneſs and curioſity as the golden one: both can transfer only their own figure.

Perhaps there is not a lily or a butterfly now in the world, but has gone through *ſix thouſand anceſtors*; and yet the work of the laſt parent is exquiſitely perfect in ſhape, in colour, and in every perfection of beauty: but it is all owing to the FIRST CAUSE.

Who can know and conſider, ſays the celebrated Dr. HUNTER, the thouſand evident proofs of the aſtoniſhing art of THE CREATOR, in forming and ſuſtaining an animal body ſuch as ours, without feeling the moſt pleaſing enthuſiaſm? Can we ſeriouſly reflect upon this awful ſubject, without being almoſt loſt in adoration? without longing for another life after this, in which we may be gratified with the higheſt enjoyment, which our faculties and nature ſeem capable of, the ſeeing and comprehending the whole plan of THE CREATOR, in forming the animal body, and in directing all its operations? The man who is really *an anatomiſt*, yet does not ſee and feel what I have endeavoured to expreſs in words, whatever he may be in other reſpects, muſt certainly labour under a dead palſy in one part of his mind. Milton could look upon the ſun at noon-day without ſeeing light: but the nerves of that organ were *inſenſible*.

The

The Mind.

The crowning gift, however, which augments the benefits accruing from all the ſenſes, is REASON.

Of the Superiority of Man above other Animals from this cauſe.

After having admitted, in its fulleſt extent, every fair *compariſon* that can be made between *man* and the moſt perfect of the *other animals*, acknowledging that *both* have bodies of matter organized in many reſpects alike; that the bodies of *both* are made up of bones, muſcles, and blood-veſſels, organs of reſpiration, circulation and digeſtion; that *both* have brain and nerves apparently of the ſame ſubſtance and texture; that in *both*, thoſe are the organs of will, of ſenſation, and of motion; that *both* poſſeſs five ſenſes of the ſame nature, and have a reſemblance in many of their appetites and inclinations; after all thoſe conceſſions, the *internal faculties* of the moſt intelligent of the brute creation will be found, upon a juſt eſtimation, at a *prodigious diſtance beneath* thoſe of men.

The actions of the one ſeeming to proceed from *the impulſe* of ſome want, the incitement of ſome appetite, or ſome controlling ſpring within them, which obliges them to perform the ſame thing in the ſame manner; ſo that all their boaſted works, the labours of every ſpecies, and every individual of the ſpecies, are as uniform as if they had been all caſt in the ſame mould.—This appears in their neſts, in their cells, for all their works which aſtoniſh us, are formed by an *inevitable neceſſity*, like *the growing* of a *plant*, or *the cryſtallization* of a *ſalt*.

One race of the moſt intelligent ſpecies *never improves* upon a *former*, nor *one individual* upon *another*.

At the end of the elephant's long life, what does he know that he did not know at the beginning? What does the *young elephant* learn from the experience of his father?

Even *attention to their young*, the moſt univerſal and moſt amiable part of the character of irrational animals, ſeems independent of ſentiment and reflection, and to proceed from *the ſame blind impulſe* which prompts them to build ſuch a kind of neſt and ſit ſuch a time on their eggs; for after a ſhort period thoſe young are *entirely neglected*, and *no trace of affection*, or *the ſmalleſt tender recollection*, ſeems any longer to ſubſiſt between the parent and the offſpring.

How *different* is this from the ſenſation of the *human ſpecies?* where the *father* and *mother* feel their youth reſtored, and their exiſtence multiplied in *their children*, whom they endeavour to turn from the allurements of *folly*, and by creating in their minds a deſire of *knowledge* and *uſeful attainments*, they ſave from the wretchedneſs of *vacancy*, and contempt, attendant upon *ignorance*; who *encourage* their exertions, *ſupport* them under diſappointment, whoſe *chief happineſs* depends on *the proſperity* of *their offspring*, and who *feel the approach* of *age without ſadneſs*, while *the evening* of their lives is *brightened* by the *riſing reputation* of *their children*.

Sometimes with a ſtrong and harmonious voice, *man* is found celebrating, in a poem, *the virtues* of a *hero*.

At other times, by *a ſtroke* of *the pencil*, he *changes* a *dull* and *flat canvaſs* into a *charming perſpective*.

Here do we ſee him, with *the chiſſel* and *graver* in his hand, *animating* the *marble*, and *giving life* to *braſs*.

There, with the *plummet* and *ſquare*, erecting a *magnificent palace*.

Now do we behold him, by the aſſiſtance of a *microſcope* of his own invention, diſcovering *new worlds*, amidſt *inviſible atoms*, or penetrating *the ſecret exerciſe* and *ſtructure* of a particular organ.

At other times, by changing this *microſcope* into a *teleſcope*, he *pierces* into the heavens, and there contemplates *Saturn* and *his Ring*.

Returning home, he *preſcribes laws* to *theſe celeſtial bodies*, *deſcribes* their paths, *meaſures* the *earth*, and *weighs* the *ſun*.

Afterwards, directing his attention towards the more uſeful ſtudy of organized beings, he dives into *the laws* of the animated fibre, examines the *relations* of different parts, and by an attentive view of their various perfections, he ſees a chain formed which comprehends the whole.

But the *moſt perfect mark* of the *greatneſs* of *man*, and of *his high exaltation above other animals*, is the *commerce* he holds with his CREATOR.

Wrapped in the thickeſt darkneſs, *the reſt* of the *animal creation* are *ignorant* of *the hand* that *formed them*.

They enjoy an exiſtence, but cannot trace the AUTHOR of life.

Man alone ſoars to GOD the principle, and proſtrate at the foot of the throne of the ALMIGHTY, he adores with the profoundeſt ſentiments of veneration, and with the moſt lively gratitude, the INEFFABLE GOODNESS that created him.

Having taken this *haſty ſurvey* of the ANIMAL ECONOMY, we now proceed to *the more particular conſideration* of the *relation we ſtand in with reſpect to the* EXTERNAL AIR, and ſhall *afterwards humbly attempt* to diſcloſe THE CAUSE of VITAL and VOLUNTARY ACTION.

SECT. I.

AIR SUPPORTS LIFE.

To ſhew "THAT AIR IS ABSOLUTELY NECESSARY FOR THE PRESERVATION OF LIFE," many have been the animals that idle curioſity has tortured in the priſon of a receiver. We ſhall, from a thouſand inſtances, produce that of the *viper*, as it is known to be a reptile exceedingly tenacious of life, and as we ſhall feel but little compaſſion for its ſufferings.

Mr. Boyle took a new caught viper, and ſhutting it up in a ſmall receiver of an air-pump, he exhauſted the air. At firſt the reptile began to ſwell, it then moved up and down as if in queſt of air, and after a while foamed, leaving the foam ſticking to the ſides of the glaſs. It continued in this ſtate 23 hours, and appeared by its poſture, even after the lapſe of two hours, *lifeleſs*. But upon the air being admitted, the viper opened and cloſed its mouth, and continuing theſe alternate motions for a few ſeconds, it ſtill argued ſome remains of life. Other creatures, in the exhauſted receiver, ſoon grow convulſed and die.

SECT. II.

THE AIR MUST BE RENEWED.

As AIR was ſhewn to be *abſolutely neceſſary for the continuance of life*, "SO IS A DUE SUPPLY OF IT INDISPENSABLE."

The ſoubah, or viceroy of Bengal, dying in the month of April, in the year 1756, he was ſucceeded by his adopted ſon SUR RAJA AL DOWLAH, a young man of the moſt violent paſſions, without faith, principle, or fortitude.

In the month of *May*, he cauſed the Engliſh factory at *Caſſimbuzar* to be inveſted, and invited Mr. Watts, the chief of the factory, to a conference; he detained him as a priſoner, and made himſelf maſter of the factory.

He then marched to *Calcutta*, and inveſted this ſettlement, which was in no poſture of defence. The *governor*, intimidated by the numbers and power of the enemy, abandoned the fort, and, together with ſome of the principal perſons reſiding in the place, took refuge on board a ſhip in the river, carrying with them their moſt valuable effects.

The defence of the place then devolved to Mr. HOLWELL, the ſecond in command; who, with the aſſiſtance of a few gallant officers, and a very ſmall garriſon, maintained the place with ſingular courage and reſolution, till at length, the enemy having forced their way into the caſtle, he was obliged to ſurrender; the ſoubah having firſt promiſed him, on the honour of a ſoldier, "that no injury ſhould be offered him or his garriſon."

Having made them priſoners, he ordered them, to the number of 146 perſons, to be put into a place called the BLACK-HOLE priſon, a cube of about 18 feet, open only to the weſtward by *two windows* ſtrongly barred with iron.

The humane reader will conceive, with horror, the miſerable ſituation to which they muſt have been reduced, thus ſtewed up, in a *cloſe ſultry night*, under the climate of Bengal, eſpecially when he reflects that many were *grievouſly wounded*, and all of them *greatly fatigued* by the exertions of the preceding day.

A *profuſe ſweat* quickly broke out on every individual, attended with an *inſatiable thirſt*, which became the more intolerable as the body was drained of its moſture.

It was in vain that they ſtript off their clothes, or fanned themſelves with their hats.

A *difficulty in breathing* was next obſerved, and every one *panted for breath.*

Mr. Holwell, who was placed at one of the windows, accoſted the ſerjeant of the guard, and endeavouring to excite his compaſſion, he drew a pathetic picture of their ſufferings, and promiſed to gratify him in the morning with a thouſand rupees, provided he could find means to remove ſome of his people into another place of confinement.

The Indian, allured by the promiſe of ſo mighty a reward, aſſured him he would uſe his utmoſt endeavour, and retired for that purpoſe.

What muſt have been the impatience at this time of theſe unhappy objects? — — — — — —
— — — — — — — —
— — — — — — — —
— — — — — — — —

In a few minutes the jemmaudar returned, *but the tyrant*, by whoſe order alone ſuch a ſtep could be taken, *was aſleep, and no one durſt diſturb his repoſe!*

The deſpair of the priſoners now became outrageous. They endeavoured to force open the door, that they might ruſh on the ſwords of the monſters, by whom they were ſurrounded, and who derided their ſufferings; but all their efforts proved ineffectual. They then uſed execrations and abuſe to provoke the guard to fire upon them.

The jemmaudar was at length moved to compaſſion. He ordered his ſoldiers to bring ſome ſkins containing *water*, which, by enraging the appetite, only ſerved to increaſe the general agitation. There was no other way of conveying it through the two windows but by hats, and this mode of conveyance proved ineffectual, from the eagerneſs and tranſports of the wretched priſoners who ſtruggled for it in fits of delirium.

The cry of *Water! Water!* iſſued from every mouth.

The conſequence of this eagerneſs was, that very little fell to the lot even of thoſe who ſtood neareſt the window; and even theſe, who were eſteemed the moſt fortunate, inſtead of finding their thirſts aſſuaged, grew more impatient.

The confuſion ſoon became general and horrid; all was clamour and conteſt; thoſe who were at a diſtance endeavoured to force their paſſage to the window, and the weak were preſſed down to the ground never to riſe again.

Mr. Holwell obſerving now his deareſt friends in the agonies of death, or dead, and inhumanly trampled on by the living, finding himſelf wedged up ſo cloſe as to be deprived of all motion, he begged, as the laſt mark of their regard, that they would for one moment remove the preſſure, and allow him to retire from the window, and die in quiet.

Even in ſuch dreadful circumſtances, which might be ſuppoſed to have levelled all diſtinctions, the poor delirious wretches manifeſted a reſpect for his rank and character: they forthwith gave way, and he forced his paſſage into the center of the place, which was leſs crowded, becauſe, *by this time*, about one third of the number had periſhed, while the reſt ſtill crowded to both the windows.

He retired to a platform at the further end of the room, and lying down upon ſome of his dead friends, recommended his ſoul to heaven.

Here his *thirſt* grew inſupportable; his *difficulty in breathing* increaſed, and he was ſeized with a *ſtrong palpitation of the heart.*

Theſe violent ſymptoms, which he could not bear, urged him to make another effort: he forced his way back to the window, and cried aloud, "*Water, for God's ſake!*"

He had been ſuppoſed already dead by his wretched companions, but finding him ſtill alive, they exhibited another extraordinary proof of regard to his perſon: "*Give him water,*" they cried, nor would one of them attempt to touch it until *he* had drank! He now breathed more freely, and the palpitation ceaſed: but finding himſelf ſtill more thirſty after drinking, he abſtained from water, and moiſtened his mouth, from time to time, by ſucking the *perſpiration*[*] from his ſhirt ſleeves, which taſted ſoft, pleaſant, and refreſhing.

The miſerable priſoners now began to perceive it was AIR and not *water* that they wanted. They dropt faſt on all ſides, and a *pungent ſteam* aroſe from the bodies of the living and the dead, as *pungent* and *volatile* as *hartſhorn*[†].

Mr. HOLWELL being weary of life, retired once more to the platform, and ſtretched himſelf by the Reverend Mr. Bellamy, who, together with his ſon, a young lieutenant, lay dead, locked in each other's arms.

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[*] Does the aqueous perſpirable fluid contain *oxygen* in looſer bond of union than water? Vide Sect. V. *On the Compoſition of Water.*

[†] Did the ſuperabundant *azot* unite with the *hydrogen* of the body, and form VOLATILE ALKALI? Vide Sect. VIII. *On the Compoſition of Alkali.*

In this ſituation he was ſoon deprived of ſenſe, and ſeemed to all appearance dead, when he was removed by his ſurviving friends to one of the windows, where the freſh air brought him back to life.

The ſoubah, being at laſt informed that the greater part of the priſoners were *ſuffocated*, inquired if the chief was alive; and being anſwered in the affirmative, ſent an order for their immediate releaſe, when NO MORE THAN 23 SURVIVED of 146 who entered into this priſon alive [*].

Another

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[*] Mr. HOLWELL and his ſurviving companions were immediately ſeized with a *putrid fever*, and in this condition even dragged before the ſoubah to be queſtioned about a treaſure, which he believed they had ſecreted. This gentleman, having denied the empty aſſertion, was, with three of his friends, loaded with fetters, and conveyed near three miles to the Indian camp, where they lay a whole night expoſed to a ſevere rain. The next morning they were brought back to the town, chained and ſuffering the ſcorching rays of a ſun intenſely hot. Then large and painful petechiæ came out, and covered their whole body. In this piteous condition they were embarked in an open boat for the capital of Bengal, and underwent ſuch cruel treatment and miſery in their paſſage, as would ſhock the humane reader ſhould he peruſe the particulars. At length the ſoubah's mother interpoſed, and he replied, with an unexpected generoſity, "*their ſufferings have been great, and they ſhall have their liberty.*"

This fact throws a great light upon the origin of *putrid fever*.—The great and good Dr. HALES, whoſe ſtudies and experiments were conſtantly directed to

Another melancholy proof of the NECESSITY OF A DUE SUPPLY OF AIR, may be drawn from the teſtimony of Dr. TROTTER, delivered before a ſelect committee of the HOUSE OF COMMONS, in the year 1790.

In July 1783, the ſlave-ſhip, in which he was, arrived at Cape *La How*, on the Gold Coaſt of *Africa*. In the ſpace of a week above *one hundred* prime ſlaves [*], *young*,

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to the benefit of mankind, recommended a trial of *ventilators* in the SAVOY and NEWGATE priſons, in both of which the *jail fever* was frequent, and commonly fatal: the good effects exceeded even his moſt ſanguine expectations; for a very ſmall portion of the ſick died, when the ventilators came into uſe, and the contagion ſeemed in a manner arreſted. The benevolent Mr. HOWARD found the priſons on the continent perfectly free from *this peſtilential fever*; owing, as he thinks, to the apartments in which the priſoners were confined being ſpacious, and conſequently well aired.

[*] Dr. TROTTER ſays, that the natives of theſe parts are *ſometimes* ſlaves from *crimes*, but the greater part of the ſlaves are, *what are called priſoners of war*. Of his whole cargo he recollects only *three criminals*; two ſold for *adultery*, and one for *witchcraft*, whoſe *whole family ſhared his fate*. One of the firſt ſaid he had been decoyed by a woman who had told her huſband, and he was ſentenced to *pay a ſlave*; but being *poor*, was *ſold himſelf*. The laſt ſaid he had had a quarrel with a *caboſheer* (or great man), who *in revenge* accuſed him of *witchcraft*, and ſold *him* and *his family for ſlaves*.

Dr. TROTTER having often aſked ACCRA, a principal trader at LA HOW, what he meant by *priſoners of war*, found they were ſuch as were carried off by a ſet of *trepanners and kidnappers*, *who ravage the country for that purpoſe*. The buſh-men making war, *to make trade* (that is, *to make ſlaves*), was a common way of ſpeaking among the traders. Having aſked, What they did *young*, *ſtout*, and *healthy*, were purchaſed. The competition, however, of the purchaſers at *Annamaboe*, whither this ſhip afterwards ſailed, ran ſo high, that the captain could not obtain more than two thirds of the uſual complement. The ſlaves were confined below ſixteen hours out of twenty-four, and permitted no exerciſe when upon deck. The rooms, where they were ſecured, are from five to ſix feet in height. Theſe rooms are imperfectly aired by gratings above, and ſmall ſcuttles in the ſide of the ſhip, which of courſe can be of little uſe at ſea. The gratings are alſo half covered, when it blows hard, to keep out the ſalt ſpray. The temperature of theſe rooms was often above 96 of Fahrenheit's

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did with their ſlaves when the nations, who traded for ſlaves with them, were at war with each other? was anſwered, That when ſhips ceaſed to come, *ſlaves ceaſed to be taken*. The practice was alſo confirmed by the ſlaves on board, who ſhewed by geſtures how the *robbers* had come upon them.

He once ſaw a black trader ſend his canoe to take *three fiſhermen* employed in the offing, who were immediately brought on board, and put in irons, and about a week afterwards he was paid for them. He remembers another man taken in the ſame way from on board a canoe along-ſide. The ſame trader very frequently ſent ſlaves on board in *the night*, which, from their own information, he found, were *every one of them* taken in the neighbourhood of *Annamaboe*. He remarked, that ſlaves ſent off in the *night*, were not paid for till they had been ſome time on board, leſt, he thinks, they ſhould be *claimed*; for *ſome were really reſtored*, one in particular, a boy, was demanded and carried off on ſhore by ſome near relations, which boy told him, he had lived in the neighbourhood of *Annamaboe*, and was *kidnapped*.

Fahrenheit's ſcale. In the evidence, of which this is an abſtract, Dr. TROTTER affirms, he could never breathe there, unleſs under the hatchways. In ſuch circumſtances the ſufferings of theſe poor creatures muſt have been dreadful. *I have often*, ſays Dr. TROTTER, *obſerved the ſlaves drawing their breath with all the laborious and anxious efforts for life, which are obſerved in expiring animals, ſubjected by experiment to foul air, or in the exhauſted receiver of an air-pump. I have often ſeen them, when the tarpawlings have been inadvertently thrown over the gratings, attempting to heave them up, crying out in their own language,* "We are ſuffocated." *Many have I ſeen dead, who the night before have ſhewn no ſigns of the ſmalleſt indiſpoſition; ſome alſo in a dying ſtate, and if not brought up quickly upon the deck, irrecoverably loſt.*

Hence, before the arrival of this veſſel at ANTIGUA, out of 650 ſlaves more than 50 had *died*, and about 300 were tainted with the SEA SCURVY*.

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* This fact throws a great light on the *origin* and *nature* of SEA SCURVY, as will be ſhewn hereafter when treating on that diſeaſe.—In our unfortunate expedition to QUIBERON there were an hundred picked horſes put on board a tender. A ſtorm coming on, the hatchways were cloſed, and theſe animals remained in this dreadful ſtate above eight-and-forty hours. Ten were found ſuffocated, and ſixty *glandered*, and communicated the diſeaſe to other horſes when they landed. So ſudden and general an infection, Mr. COLEMAN, the Veterinary

Mr. Wilson ſtates, that in his ſhip, and three others belonging to the ſame concern, they purchaſed among them 2064 ſlaves, and *loſt* 586. He adds, that he has known ſome ſhips in the ſlave trade bury a *quarter*, ſome *a third*, and others even *half* of their cargo *.

To mention no other fact, a ſtrong proof of THE NECESSITY OF A FREQUENT RENEWAL OF THE AIR, may be found in the Records of the Dublin *Lying-in Hoſpital.*

Veterinary Profeſſor, thinks could not have happened from the ſuppoſition that a glandered horſe, by ſome overſight, had been ſhipt along with the reſt, as it requires a week before this diſorder could have infected others (as in the ſmall-pox, &c.), and attributes the origin of *glanders*, in this inſtance, ſolely from the ſtived ſituation in which theſe poor animals were placed.

* Even on the preſent regulated plan the ſituation of the ſlaves muſt be dreadful; for their bodies touch each other, and many of them have not room to ſit *upright*.

Ye bands of ſenators! whoſe ſuffrage ſways
Britannia's realms, whom either Ind obeys;
who right the injured, and reward the brave,
ſtretch your ſtrong arm, for *ye have power to ſave!*
Throned in the vaulted heart, his dread reſort,
inexorable conſcience holds his court;
with ſtill ſmall voice the plots of guilt alarms,
bares his maſked brow, his lifted hand diſarms;
but, wrapt in night with *terrors* all his own,
He ſpeaks in thunder, when the deed is done.
Hear him, ye ſenates! Hear *this truth* ſublime,
HE, WHO ALLOWS OPPRESSION, SHARES THE CRIME.

Dr. Darwin.

In this hoſpital 2944 infants out of 7650 died in the years 1782, 1783, 1784, and 1785, within the firſt fortnight after their birth, that is, nearly *one child* out of every *ſix*. They almoſt all died in convulſions, of what the nurſes called *nine-days fits*, becauſe they came on within nine days after their birth. Theſe children, many of them, foamed at their mouths, their thumbs were drawn into the palms of their hands, the jaws were locked, the face was ſwelled and looked *blue*, as *though they were choaked.*

This laſt circumſtance led Dr. CLERK to conclude that the rooms in the hoſpital were too *cloſe* and *crowded*, and hence the infants had not a ſufficient ſupply of *good air* to breathe. This benevolent phyſician contrived, therefore, *air-pipes*, 6 inches wide, which were placed in the ceiling of each room. Three holes, an inch wide, were bored through each window frame; and a number of holes were made in the doors at the bottom.

By theſe contrivances the rooms were kept *ſweet* and *freſh*; and the *conſequence* has been, from the regiſter in that hoſpital, that, Children.

In 1786, out of 1372 there died 51
1787, —— 1375 —— 59
1788, —— 1496 —— 55
4243 165

Now if out of 4243 children there periſh, *when the hoſpital was ventilated*, only 165 infants, how many may be expected to die out of 7650, the number of children born in the DUBLIN *Lying-in Hoſpital* in the years 1782, 1783, 1784, and 1785?

The anſwer is, by the rule of proportion,—279. But how dreadful the account, there *died* abſolutely 2944*, that is 2665, ſolely *from the want of a due ſupply of air!*—and we have not only to deplore the number of innocent victims who were deſtroyed in theſe few years and previous to them, but alſo to lament the wretched anguiſh of the diſconſolate parents, and the impoveriſhed ſtate of health in many of the poor babes who ſurvived this great ſlaughter.

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* Vide line 1, page 57.

SECT. III.

WHY THE AIR MUST BE RENEWED.

HAVING proved the connection betwixt *life* and *air*, it is neceſſary now to ſhew WHAT ARE THE CHEMICAL ALTERATIONS AIR UNDERGOES BY BEING RESPIRED.

Dr. PRIESTLEY having formed *nitrous air* by the ſolution of various metallic bodies in *nitrous acid*, he diſcovered that it poſſeſſes this ſingular property, that when mixed with *common air*, a great *diminution* of the bulk of the 2 *aerial fluids* takes place, attended with a turbid red, or deep orange colour, and a conſiderable heat.

I hardly know, ſays this philoſopher, any experiment, that is more adapted to amaze than this, which exhibits a quantity of *air*, which, as it were, devours a quantity of *another kind of air*, half as large as itſelf, and yet, inſtead of acquiring *larger dimenſions*, becomes itſelf *conſiderably contracted*.

We are not ſo much ſurpriſed when we find an *aeriform body* ſtarting out from a *ſolid ſubſtance*, as in the formation,

formation of *nitrous* and *other factitious airs*; but we are more ſenſibly affected, when, on the reverſe, *two inviſible aerial bodies* are converted into a *compact coloured fluid*; for, like condenſed ſteam, they occupy, in *compariſon* with their former dimenſions, ſcarcely any perceptible *ſpace*. Here the *nitrous air* attracts to itſelf *oxygen*, the baſe of vital air, *caloric* is given out, and *this combination* gives us *nitrous acid*.

This diſcovery * was a moſt agreeable one to me, adds this great experimentaliſt, as I hope it may be an *uſeful one* to the public. It is remarkable that *this air* occaſions no effervеſcence or *diminution* with *fixed* or *inflammable airs*, but only with AIR FIT FOR RESPIRATION *and* COMBUSTION, and, as far as I can judge, *exactly in proportion* to *its fitneſs for that purpoſe* †; ſo that by this means the *goodneſs* of any air may be diſtinguiſhed much more accurately, than by putting into it a mouſe, or any other animal, to try how long it can exiſt in any given quantity. By *this teſt* I was enabled to perceive a *real difference* in the air of my *ſtudy*, after a few perſons had been with me in it, and the air on the *outſide of my houſe*. A phial of air being ſent me from the neighbourhood of YORK, it appeared to be not *ſo good* as the air near LEEDS; that is, it was not DIMINISHED *ſo much* by an *equal* mixture of *nitrous air*.

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* This fact was known to MAYOW, but practically employed as a teſt of goodneſs of air firſt by Dr. PRIESTLEY.

† That is in proportion to the quantity of OXYGEN AIR it contains, which will preſently appear to be the PABULUM VITÆ, *or principle of life*. It was ſhewn in the former part of this work, that *atmoſpheric air* is a compound of *two diſtinct* and *ſolid ſubſtances*, *oxygen* and *azot*, rendered *aerial*, by the ſuſpenſive power of *caloric*, or *fire*. Vide p. 14.

The juſtly celebrated chemiſt LAVOISIER, aſcertains the proportion of *vital air*[*] contained in any given quantity of *common air* by the means of *phoſphorus*. His EUDIOMETER is thus conſtructed. Having filled a cylindrical glaſs tube with quickſilver, he immerſes it in a baſon of the ſame fluid. He then puts into it *the air*, the purity of which he propoſes to examine. He afterwards paſſes up the *phoſphorus*, and having heated an iron wire at the extremity red hot, he applies the hot end to the *phoſphorus* through the quickſilver, which quickly conſumes[†], and the quickſilver *riſes* nearly 27 diviſions (if the tube has been accurately divided into 100 parts[*]); after which time, if any *phoſphorus* remains, it ceaſes to burn, there being no more *oxygen* in the tube to be attracted by the *phoſphorus*[†].

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[*] The reader has already learnt, from the diſcoveries of LAVOISIER, that ATMOSPHERIC AIR conſiſts of *two parts*, viz. *oxygen air*, blended with *azotic air*, which by chemical means may be ſeparated, and confined in different jars, and that a mouſe, or any other animal, will live a conſiderable time in the *one*, being lively, briſk, and active; whilſt, in *the other*, he ſoon languiſhes and dies. *This part* of the air, therefore, as ſo much contributing to *life*, is with the utmoſt propriety denominated by phyſicians, VITAL AIR.

[†] *Phoſphorus*, like other combuſtible bodies, attracts *oxygen*, the particles being once ſeparated beyond their ſphere of mutual attraction, or *the attraction* of

By *this means* LAVOISIER aſcertained, that when the *air out of doors* conſiſted of

27 parts OXYGEN AIR,
and 73 —— AZOTIC AIR,
100 parts;

The air in the loweſt ward in the GENERAL HOSPITAL at *Paris*, contained

but 25 parts of OXYGEN AIR,
and 71 —— of AZOTIC AIR,
and 4 —— of *fixed air*,
100 parts.

of coheſion. The *caloric*, which is diſengaged from the *attracted oxygen*, anſwers the ſame purpoſe as the *hot iron* which firſt kindled the *phoſphorus*. The *phoſphorus* becomes, in conſequence of this union with *oxygen*, *phoſphoric acid*.

[*] In 100 parts of atmoſpheric air, there is moſt commonly found 27 of *oxygen air*; or in other words, in 100 *gallons of air*, there would be found 27 *gallons* of *oxygen air*, and 73 of *azotic air*.

[†] This clearly evinces that *combuſtion* is the divorcement of *oxygen* from *caloric*, which *being ſet at liberty*, aſſumes, as it is eſcaping, the character of *flame* or *fire*, for the *phoſphorus* no longer burns, than while *oxygen air* is preſent, and the *phoſphoric acid* will have an *increaſe of weight* exactly correſponding to the *weight* of *oxygen air conſumed*; that is, 100 parts of *phoſphorus* will abſorb 154 parts of *oxygen* or *vital air*.

This proportion varied in different parts of the ſame room. At the *top* the air had ſuffered much more injury. It contained

but 18½ parts of OXYGEN AIR,
and 79 —— of AZOTIC AIR,
and 2½ —— of *fixed air*,

100 parts.

And when, before the play, the *air* in the THEATRE in the Thulieries contained

27 parts of OXYGEN AIR,
and 73 —— of AZOTIC AIR,

100 parts;

Towards the concluſion of the piece, which was acted before an unuſual concourſe of ſpectators, it contained

but 21 parts of OXYGEN AIR,
and 76½ — of AZOTIC AIR,
and 2½ — of *fixed air*,

100 parts.

Whence it is evident, that the *quantity* of OXYGEN, or VITAL, AIR had been diminiſhed in the theatre in the proportion of 27 to 21, or nearly *one fourth*; that is, it was ONE FOURTH LESS FIT FOR RESPIRATION THAN BEFORE.

The air of the atmoſphere, therefore, which is originally compoſed of 2 *fluids*, is compoſed of 3 *aerial fluids*, in all places which contain numerous aſſemblies of people. *Theſe* 3 *aerial bodies*, though blended together, arrange themſelves in ſome degree according to their ſpecific gravities; that is, the proportion of AZOTIC AIR, which is the lighter body of the three, will be found moſt in the *upper part*, the OXYGEN AIR in the middle, and the FIXED AIR will be found moſt in the *lower part* of the apartment.

This occaſions a circulation in the air, for, in ſpite of the architect, the *rarefied air* will aſcend, the *fixed air* ſink, and the *colder* and *purer air* ruſh into the apartment through every crevice*.

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* To render the CIRCULATION of the air *ſenſible*; if the air of a room be *heated* by a fire in it, whilſt the air in a contiguous room is *cold*; then let the door between theſe two rooms be opened, in which caſe the *hot air* of one room being *rarefied* will paſs through the *upper part* of the opening of the door into the cold room; and on the contrary the *cold air* of the other room being *heavier*, will paſs into the former through the *lower parts* of the opening. This may be proved by applying a candle at the *top* and *lower parts* of the opening between the two rooms. The direction of the flame of the candle will point out the *contrary currents of air*. It is for this reaſon that when a fire

Unleſs *this were the caſe*, and unleſs *the air was conſtantly renewed*, the ſpectators would be expoſed to the moſt fatal accidents long before the concluſion of the performance.

To convince ourſelves of this truth, nothing more is neceſſary than to take the example of a room, let it be ſuppoſed 30 feet long by 25, and 30 feet high.

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fire is lighted in a chimney, a *ſtrong current of air* enters the room, which may be felt by applying the hand near the key-hole, or other ſmall openings, if the doors and windows be ſhut. It is in this way that a fire is ſaid to purify a room: but this effect is only becauſe the fire promotes the *circulation* of the air, and dries the dampneſs of the apartment: ſo that it is not the infected air that is purified, but a *new*, *freſh*, and *wholeſome air*, by the action of fire, that is made to take place of a bad and corrupt air. Hence it appears, that thoſe perſons are miſtaken who are over-anxious in keeping out the air from entering the apartments of convaleſcent perſons, by *accurately ſtopping*, *by liſt*, *linings*, and *ſand-bags*, *all the ſmalleſt openings that admit freſh air*.

I cannot forbear mentioning here, as it relates to health, the method for preventing *ſmoky chimneys*. The particles of air, which are expanded by the fire, being lighter than thoſe particles which are not heated, juſt as a cork riſes, if placed at the bottom of a tub of water, ſo muſt the *rarefied air* aſcend and paſs up the chimney, as being the lighter body of the two. If we conceive the figure of a FRENCH HORN, it is evident that *the volume of air* contained *in the mouth-piece*, would be *ſooner heated* than *that at the baſe*, and therefore the *rarefaction of air* be more certain, were any given quantity of heat applied to the *ſmaller* than the *larger portion of air*. It is thus with chimneys, the more they reſemble the *French horn*, the more certain the aſcent of the ſmoke, for the *ſmaller* the *portion of air* at the bottom, the *ſooner* will it be heated, and the BALANCE at the *lower* and *upper parts* of the chimney being deſtroyed, the *lighter air* cannot but aſcend and carry with it the ſmoke.—THE APERTURE at the *bottom* of chimneys ſhould, therefore, be *ſmall*.

A room of theſe dimenſions would contain 100 ſpectators. Now ſince each perſon conſumes about 5 cubic feet of air in an hour, that is, deprives ſuch a quantity of air of its OXYGEN or *vital principle*, it would follow, that as ſuch a room could contain only 22,500 cubic feet of air, that unleſs the air was conſtantly renewed it would be rendered completely mephitic or noxious in about *four hours and an half*, and it is probable that the greater part of the audience would be ſeriouſly incommoded, or even periſh, long before the end of that period *.

The ſame calculation applies to all confined places, where a number of perſons are aſſembled together: eſpecially if the air circulates in them ſlowly, or with difficulty: *the oftener it is reſpired the more it will become vitiated*; and it is eaſy to obſerve how the attention of the audience fails them in ſuch places. They can no longer liſten to the diſcourſe. The irritating quality of the mephitic air excites a general coughing. The preacher now receives none of thoſe marks of attention or reſpect, which in more favourable circumſtances he had a right to expect. They experience a drowſy head-ach. They expreſs even a phyſical anxiety to be gone, and the congregation feel themſelves on returning home jaded, and till revived by a *more wholeſome or oxygenated air* they look wan, like perſons who are ready to faint away.

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* The affecting narrative of the BLACK HOLE of CALCUTTA, and the DUBLIN LYING-IN HOSPITAL, are melancholy confirmations of the truth of this ſuppoſition of LAVOISIER. Vide Sect. I.

We now ſee the reaſon why Dr. THORNTON, in a letter to Dr. BEDDOES, the celebrated Profeſſor of Chemiſtry at Oxford, and inſtitutor of the *Pneumatic Practice*, ſays, that he is perſuaded OXYGEN GAS would be found of great ſervice, if diffuſed at certain ſeaſons, in *mines*, in *churches*, in *crowded rooms* *, in the *chambers*

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* A lively young lady, who came to BATH, to put herſelf under the care of Dr. MAKITTRICK ADAIR, gave a rout, and inſiſted that he ſhould be of the party. The room was *ſmall*, and the company very *numerous*. He had not been long ſeated at the card-table, before a young gentleman, his partner, *fell into a ſwoon*. The doors were immediately thrown open to afford him freſh air, and the ſaſh lifted up, and both the gentleman who ſwooned, and the young lady, Dr. ADAIR's patient, who were invalids, were much injured by the ſudden expoſure to a current of cold air. How the reſt of the company were affected, ſays Dr. ADAIR, I had not an opportunity of knowing; but my own feelings and ſufferings for many hours after I retired from *this oven*, convinced me of the *dangerous conſequences* of *ſuch meetings*. On declaring a few days after, to one of my brethren, a man of humour, my reſolution of writing a bitter philippic againſt routs, he archly replied, "Let them alone, Doctor, how otherwiſe ſhould *twenty-ſix* phyſicians ſubſiſt in this place!"

If a ſmall tube, opening into the apartment deſigned for ROUTS, was to communicate with the outward air, the external orifice of the tube being made *ſomewhat* *bers* of the ſick, in *hoſpitals*, and other *public buildings*, and eſpecially in the *bathing-rooms* at BATH, where great *faintneſs* is often brought on the patients who are bathing by breathing a *reduced atmoſphere* from the extrication of AZOTIC AIR, which is given out in a conſiderable quantity by thoſe waters*.

SECT.

ſomewhat ABOVE THE LEVEL *of the room*, the fire and breath of the aſſembly would have no ſooner heated the air, than it would riſe immediately *upwards*, ſo as to fill more particularly the higher parts of the room ; and, as other particles would be ſucceſſively heated and rarefied in their turn, by their expanſive force they would preſs upon the upper ſtatum of air, ſo as to force the *lighteſt particles* through the opening left for that purpoſe in the ceiling of the room, by which contrivance the *foul and hot air* of the apartment would be *gradually drawn off*.

But in order *to admit freſh air* into the drawing-room, if another opening be made in the ceiling of the room, having a communication with a ſmall pipe that ſhould lead from thence to the outſide of the houſe, and extend *ſome way* BENEATH THE LEVEL *of the room:* in this ſituation the *cool external air* would be forced in at the lower opening of the tube, and aſcend into the apartment in proportion to the quantity that eſcaped from the upper region by means of the other tube : and ſince weighty air would no ſooner enter the room than it would tend downwards by its own natural gravity, it would gradually be heated by the warm air in its deſcent, and would thus be diſperſed about the room, ſo as *mildly* and *imperceptibly* to reach the company, and ſupply them with a ſufficient quantity of freſh and vivifying air, without any of thoſe inconveniencies to which the company are ſubjected by the uſual way of admitting *freſh air*. This ſimple contrivance might be made alſo as *elegant* as it muſt be *beneficial*. Vide note p. 17.

* The expence and trouble of diffuſing *oxygen air* is at preſent an objection, but let us reflect that in every hundred weight of MINIUM OR RED LEAD, there is combined about 12 *pounds* weight of *oxygen*, or *pure, air*. Now as 60 pounds of water are about a cubic foot, and as oxygen air is eight hundred

times

SECT. IV.

THE CHEMICAL ALTERATION AIR UNDERGOES BY BEING RESPIRED.

It was ſhewn in the laſt ſection, that if an animal be confined under a bell-glaſs, where all admiſſion of freſh air be denied, the air which before conſiſted of 2 *aerial fluids*, viz.

1. OXYGEN AIR,
and 2. AZOTIC AIR,

will preſently conſiſt of 3 *aerial fluids.*

I. OXYGEN

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times lighter than water, 500 weight of MINIUM or RED LEAD ſhould produce 800 *cubic feet of oxygen air*, or about 6000 *gallons*. And, ſince the ſubſtances, which contain *oxygen*, or *vital, air*, in immenſe quantities, are of little value, we have a right to expect, that a perfect, ſalubrious, *pure air*, may, as chemiſtry advances, be obtained from ſuch materials by a *cheap* and *eaſy proceſs*.—Dr. DARWIN.

It has been computed by the Abbé FONTANA, that a pound of *nitre*, calcined in a cloſe veſſel, yields 12,000 cubic inches of VITAL AIR. It is ſingularly curious that a ſubſtance of ſuch very humble pretenſions as common *nitre* (ſalt-petre) ſhould poſſeſs properties on which hangs the fate of the moſt powerful empires! Since by chemiſtry it may either be converted into a fulminating engine, to overturn fortified cities, and to enable the garriſon to launch out death and deſtruction on the beſiegers: Or,—that by a different proceſs, it may be made to pour forth VITAL AIR, that VIVIFYING FLUID diffuſed through the atmoſphere, which breathes in the zephyrs,

1. OXYGEN AIR, *in a diminiſhed quantity*,
2. AZOTIC AIR,
and 3. *fixed air*.

At length the OXYGEN AIR being conſumed, the animal will ceaſe to live, and the air in the bell-glaſs will be found to conſiſt now of 2 *aerial fluids* only, that cannot maintain life, viz.

1. AZOTIC AIR,
and 2. *fixed air*.

A queſtion naturally ariſes, WHAT HAS BECOME OF THE OXYGEN, OR VITAL, AIR, deprived of which an animal *dies?*

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which whiſpers in the breeze, and which cheers and ſupports all animated Nature!

How many thouſand tons of *nitre* has Europe conſumed of late, in making gunpowder, and that with the avowed intention of DESTROYING thouſands of its inhabitants! Might not a ſmall portion be ſpared for another purpoſe, at leaſt equally humane and laudable, viz. that of PRESERVING an unfortunate fellow creature! Should *the preſent* advanced price of *nitre*, however, render the preparation of VITAL AIR too expenſive a *remedy*, the latter may be obtained by a ſimilar proceſs from *mangameſe*. Beſides, the VITAL AIR from *manganeſe* has been lately diſcovered to be of ſuperior quality, and in greater abundance; a circumſtance of *no ſmall importance*, now that the demand for VITAL AIR, on account of *medicinal purpoſes*, is daily increaſing; nor is that to be wondered at, ſince the new light, which it continues to reflect on the *œconomy*, has already began to dawn on the *pathology*, a circumſtance which ſeems to denote, that a very material REVOLUTION in the practice of phyſic is at no great diſtance.—From Dr. FOTHERGILL's Eſſay, *On the Suſpenſion of Vital Action,* to which was adjudged, by the *Medical Society* of LONDON, the *prize* of a GOLD MEDAL.

OFFICE

OFFICE OF THE LUNGS

In the lungs the blood coming into contact with ATMOSPHERIC AIR [*] works many *chemical* alterations in it.

Here it is (in the cells of the lungs) that the dark blood, throwing off attenuated *carbon*, forms with the VITAL AIR of the atmoſphere,—FIXED AIR [†]:

Here it is, that the purple blood parts with its *hydrogen*, which, uniting with the VITAL AIR, forms—the HUMID VAPOUR that iſſues from the mouth [‡].

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[*] "*Reſpiration* we cannot explain: we only know," ſays Dr. HUNTER, in his Introductory Lecture which he publiſhed in the year 1784, "that it " is, *in fact*, eſſential and neceſſary to life. Notwithſtanding this, when we ſee " all the other parts of the body, and their functions, ſo well accounted for; " we cannot doubt but that *reſpiration* is ſo likewiſe. And IF EVER we ſhould " be happy enough to find out clearly the object of this function, we ſhall " doubtleſs, as clearly ſee, that THIS ORGAN is as wiſely contrived for *an important office*, as we now ſee the purpoſe and importance of the HEART, and " vaſcular ſyſtem; which, till the circulation of the blood was diſcovered, " was wholly concealed from us." If this learned teacher was to riſe from the grave, I believe, no ſubject would give him higher delight than to behold, iſſuing from the furnaces of the chemiſt, a new and ſimple philoſophy, which has clearly developed the *nature* and *neceſſity* of *reſpiration*.

[†] This is proved by making an expiration through a tube containing *lime-water*, which will become inſtantly *turbid*.—Or if black blood be confined in a phial containing *vital air*, the whole of *that air* will be converted into *fixed air*. Vide note *, p. 73.

[‡] This you may prove by placing venal blood in *vital air*, when the ſides of the veſſel will be covered with large drops of *water*.—Or if black blood be received into a phial containing *azotic air*, *ammoniac* will be formed, which was ſhewn by BERTHOLET to be nothing more than *hydrogen* combined with *azot*. Vide Part I. p. 39.

And here it is, that the *dark blood* (having thrown off *hydrogen* and *carbon)* IMBIBES the VITAL AIR, which changes its *purple colour* to a *brilliant red.*

I. EXPERIMENTS TO PROVE THAT PURPLE VENAL BLOOD ABSORBS OXYGEN AIR.

If blood be taken from a *vein*, it readily ſeparates into 2 parts, a thin ſemi-tranſparent fluid called *ſerum*, and the *craſſamentum*, floating on it.

This firm ſubſtance at firſt appears of a *dark purple colour inclining to black*, but ſoon it aſſumes on *its upper ſurface a bright ſcarlet appearance*, reſembling the blood contained within *an artery.*

To prove that *this florid colour* is owing to the abſorption of *oxygen air* (one of the principles of *common air*), the illuſtrious Dr. GOODWIN encloſed a quantity of *vital air* in a glaſs receiver inverted over quickſilver, and introduced into it 4 ounces of blood freſh drawn from the *jugular vein* of a ſheep: the blood became inſtantly *very florid*, and the quickſilver ſeemed to *aſcend* a little in the receiver. To aſcertain this latter circumſtance, I repeated, ſays he, the experiment three or four times: *the change of colour* in the blood was always *very ſudden*, and after ſeveral minutes the quickſilver *aſcended* two or three lines.

If OIL be ſpread on the ſurface of the blood, which will prevent the contact of air, no ſuch alteration as to colour takes place.

GIRTANNER, who turned his thoughts much to this ſubject, diſcovered that *venal blood* not only aſſumed a *bright vermilion colour* when expoſed to *oxygen air*, but gave out *carbon* and *hydrogen*, which uniting with the *oxygen air*, formed *fixed air* * and *water* †, which was found on the ſurface of the quickſilver.

II. EXPERIMENTS TO PROVE THAT CRIMSON ARTERIAL BLOOD CONTAINS OXYGEN AIR.

The *arterial blood* from the carotid artery of a ſheep was received into a bottle full of *azotic air*. The blood from a *bright red* ſhortly aſſumed the *deep colour of venal blood.* On opening the bottle the next day, the *azotic air* which it before contained was found mixed with *oxygen air*, ſo that an animal could live in it, and a candle burnt in it for near two minutes.

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* *Charcoal* and *oxygen air*. Vide Sect. VI. The Analyſis of Fixed Air, or Carbonic Acid Air.

The preſence of *fixed air* is aſcertained by *lime water*; for water diſſolves *lime*, and holds it ſuſpended. The ſolution then appears perfectly clear and bright. If any *fixed air* comes into contact with the water, the *carbonic acid* ſeizes on the *lime*, and makes with it a combination *inſoluble* in *water*. The *lime*, in that caſe, is *viſible* in the water. *Lime water* is therefore a teſt of the preſence of *fixed* or *carbonic acid air*.

† *Hydrogen* and *oxygen*. Vide Sect. V. On the Compoſition of Water.

This experiment proves deciſively that *arterial blood* contains *oxygen air*, and that as ſoon as it parts with *this air* it then reaſſumes the true *venal character*.

The *arterial blood* of the carotid artery of a ſheep was received into a bottle full of *nitrous air*. The blood aſſumed a *green* colour* upon the ſurface. A ſmall quantity of greeniſh ſerum was ſeparated. The day after, on opening the bottle, the vapour of *nitrous acid* was obſerved by all who were preſent.

Here then is an experiment which alſo proves *the preſence* of *oxygen air* in the *arterial blood*; ſince it is from this circumſtance alone that it is capable of changing *nitrous air*, into *nitrous acid* †.

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* Dr. GIRTANNER having injected ſome *nitrous air* into the *vein* of a dog, when it came into contact with the common air admitted into the lungs, *nitrous acid* was formed, and the lungs aſſumed in conſequence a *greeniſh hue*. The blood returned by the veins to the heart was found *black*.

† Vide Sect. III. An account of Dr. *Prieſtley's* Teſt of the Purity of the Air by means of Nitrous Air.

III. DR.

III. DR. GOODWIN'S CELEBRATED EXPERIMENTS.

But that no poſſible doubt might exiſt, that *oxygen air* is imbibed *by the blood* in *the lungs*, Dr. GOODWIN opened the cheſt of a living dog.

The LUNGS and HEART were then expoſed to view.

The blood, which was driven from the RIGHT VENTRICLE of the heart into the PULMONARY ARTERY*, appeared of a *dark venous complexion.*

It certainly was a ſtriking ſpectacle to obſerve the *black blood* as it returned from the lungs by the four PULMONARY VEINS† of the LUNGS, in its paſſage to the LEFT AURICLE of the heart, appear of a *bright vermilion colour.*

It was ſoon found neceſſary to inflate the lungs by artificial means.

If at any time this was intermitted, the blood in the four PULMONARY VEINS appeared of a *dark purple colour*, and the LEFT DIVISION of the heart receiving *black blood*, a *diminution* of the pulſations of the HEART

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* Vide Map of the Heart, figure (5), page xxiii.

† Vide Map of the Heart, figures (8), (9), (10), (11), page xxiii.

and ARTERIES took place, and in a little time all *their actions* ceaſed.

But if at this time the LUNGS were made by the *inflation* of common air alternately to collapſe and diſtend, the blood in the PULMONARY VESSELS regained its former *crimſon colour*, and *the action* of the HEART and ARTERIES was *excited anew*.

Thus, if we open the breaſt of a frog, and ſtop the trachea, or windpipe, we obſerve, firſt, its pulmonic blood *florid*, and the heart beating ſtrongly; ſecondly, ſome time after, the pulmonic blood has become of a *dark colour*, and the heart's motion has grown languid; after this, the pulmonic blood becomes *black*, and the pulſation of the heart ceaſes; and, laſtly, the trachea of the frog being untied, and the creature allowed to breathe again, the blood becomes *crimſon*, and the heart acts with its priſtine vigour *.

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* Vide Sect. VI. where it is ſhewn, that the pulſation of the heart and arteries depend upon the ſtimulus of *oxygen* in the blood.

SECT. V.

THE CIRCULATION OF THE BLOOD.

THE CIRCULATION OF THE BLOOD was the fortunate diſcovery of the immortal HARVEY, and has paved the way for all the great improvements that have ſince been made in the ſcience of medicine.

I cannot help obſerving here, that *this doctrine* at firſt met with univerſal oppoſition, and that it was remarked, that no phyſician, paſt the age of forty, believed in it; and in conſequence the practice of this great and good man declined from the moment he publiſhed to the world his ever memorable diſcovery.

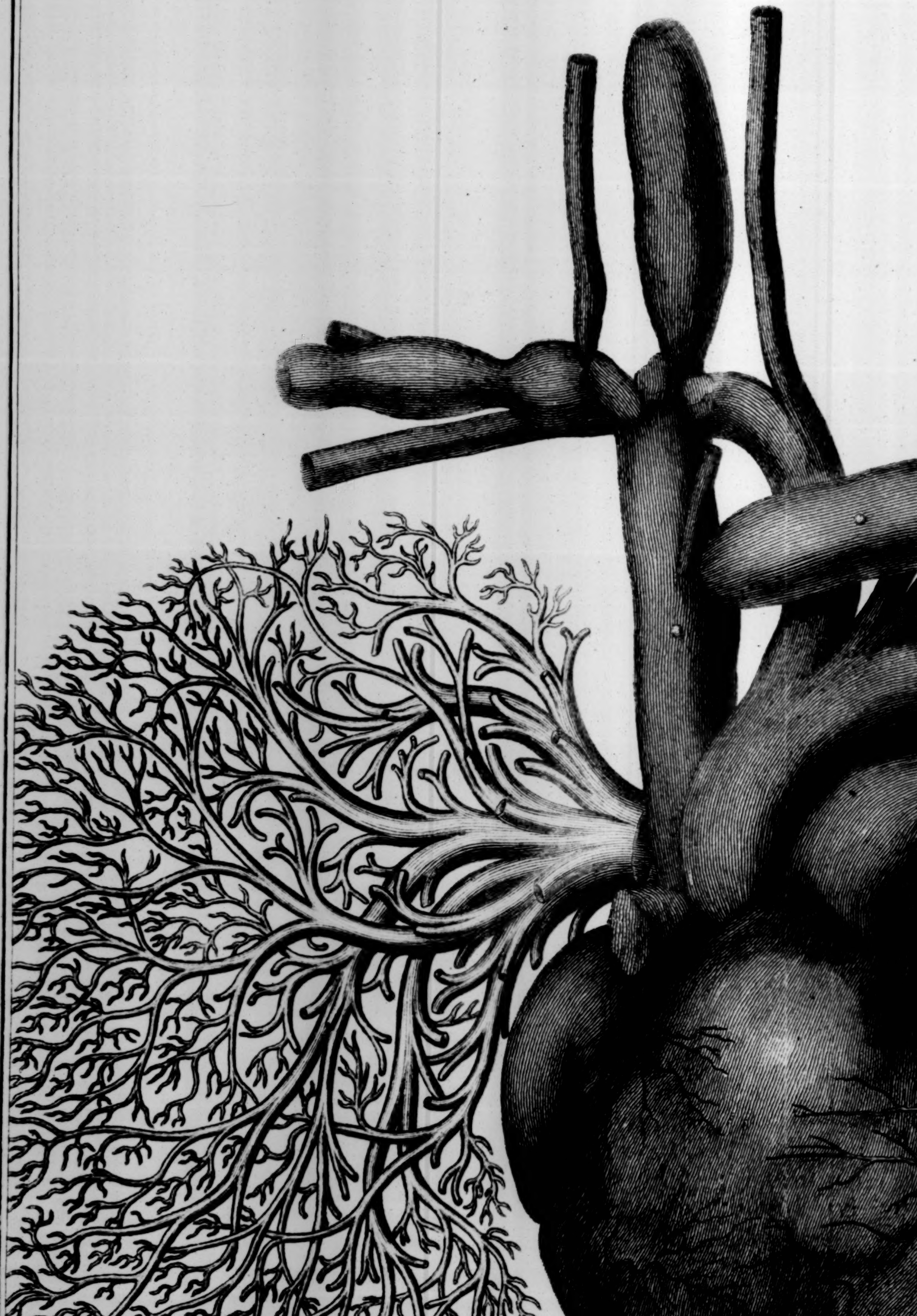
The new doctrine at length getting into vogue, the *ſenior* phyſicians, ſays MALPIGHI, were inflamed to ſuch a pitch at BONONIA, that in order to root out heretical innovations in philoſophy and phyſic, they endeavoured to get an act paſſed, whereby every graduate ſhould be obliged to take the following *additional clauſe* to his ſolemn oath on receiving his degree; "*You ſhall likewiſe ſwear that you will, with all your might* (PRO TOTO TUI POSSE) *preſerve and defend the doctrines of* HIPPOCRATES, ARISTOTLE, and GALEN, *which are taught in this univerſity,*

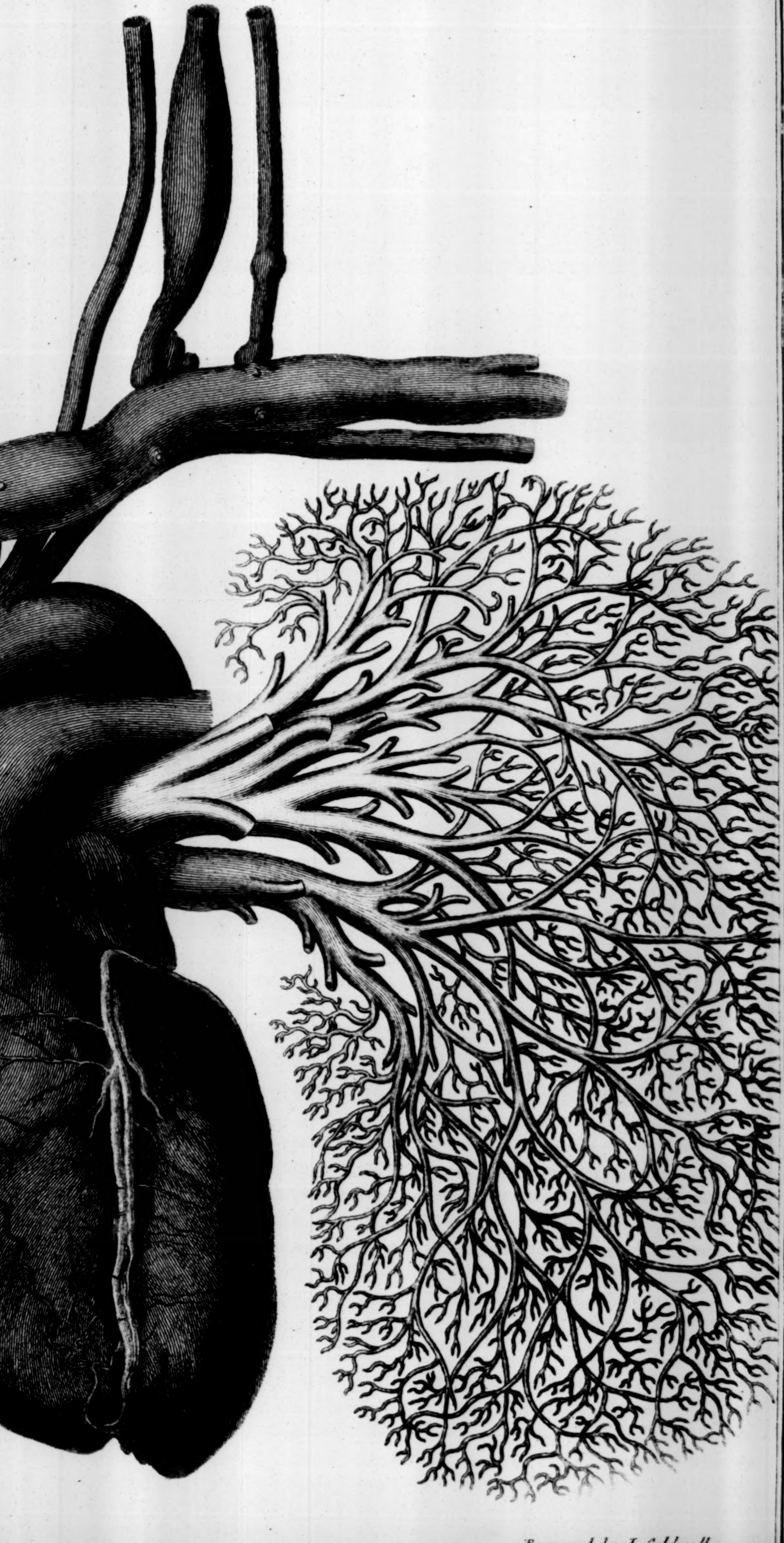
verſity, and have been approved of during a long ſeries of ages; and that you will not permit their principles and concluſions to be overturned by any perſon whatſoever."

Here it may be uſeful, adds the juſtly celebrated Dr. HUNTER, as well as entertaining, to remark, that *improvements* in medicine have always been among men an object of contention. A little reflection on human nature will ſhew that VANITY is the principle ſource of *this abſurdity.* All men wiſh to be reſpectable; and moſt of them to paſs in the world, *for what they are not*; for being *ſo very acute*, *judicious*, and *learned*, as to need *no new inſtructions.* Hence profeſſors aſſume a decided and dictatorial character, affecting to have gone to the *bottom of every thing*, and to have *overcome every difficulty*, either by the natural powers of their underſtandings, or by the ſeverity of their ſtudies, and perſeverance in the purſuit of knowledge. Old men, beſides, can ſeldom bear, what they think an inverſion of the natural order of things, that younger perſons ſhould inſtruct them. Of all men, *teachers* of every kind bear this with moſt impatience. For that reaſon we ſee, in fact, that the ſeniors of ſchools, colleges, and public foundations, have generally been the moſt obſtinate *in ſhutting out light*, and claiming a *birth-right* for *opinions*, as for *property.*

It

Back view of the Heart





Engraved by J. Caldwall

It is eaſy to ſee that ſuch men will reſiſt *new doctrines* with more obſtinacy than the reſt of mankind, perhaps with INVETERACY, in proportion as the doctrines *are well founded* and *readily credited.* They will be ſenſible that many perſons who embrace the *new opinion*, will call to mind *many looks of importance*, and *expreſſions of vanity*, which muſt *now* appear truly contemptible. Dr. HARVEY, before his death, had the happineſs, however, to find the clamours of ignorance, envy, and prejudice, ſilenced; and *profeſſional men* grew at laſt aſhamed to own, that they had *ever* combated or diſbelieved the CIRCULATION OF THE BLOOD.

But to return to the object of this ſection.

All the veins of the body falling into *two trunks*, viz. the ASCENDING (1), and DESCENDING, CAVA (2), empty themſelves into THE RIGHT AURICLE of the heart (3). *The right auricle* unloads into THE RIGHT VENTRICLE of the heart (4), *which* throws the blood through THE PULMONARY ARTERY (5) into *the lungs*, by its *two branches* (6) (7), which go to the *right* and *left lobes*.

From *the lungs* the blood is brought back by THE *four* PULMONARY VEINS (8), (9), (10), (11), into THE LEFT AURICLE (12), and from thence it paſſes into THE LEFT VENTRICLE (13), by *which* it is diſtributed through *the body* by means of THE AORTA (14), and its branches. *Theſe* terminate in *the veins* of the body, which collect the blood and bring it back to the heart by the TWO CAVÆ (1) (2). Or, in other words,

The HEART is divided into 2 *parts* by a *longitudinal* ſeparation. *Theſe* 2 *parts* are formed into 2 *cavities* by a *lateral* ſeparation.

The VEINS* enter the 2 *upper cavities*, or AURICLES, and the ARTERIES† go out from the 2 *lower cavities*, or VENTRICLES.

When the AURICLES contract, the blood is driven into the VENTRICLES; and when THESE contract, it is forced into the ARTERIES.

Then *commences*, in fact, THE DOUBLE CIRCULATION OF THE BLOOD.—The ARTERIES† contract, and the blood flows from the *right diviſion* of *the heart* THROUGH THE LUNGS to enter the *left diviſion* of *the heart*:—and from the *left diviſion* of *the heart*, the blood paſſes THROUGH THE VARIOUS PARTS OF THE BODY to enter again the *right diviſion* of *the heart.*

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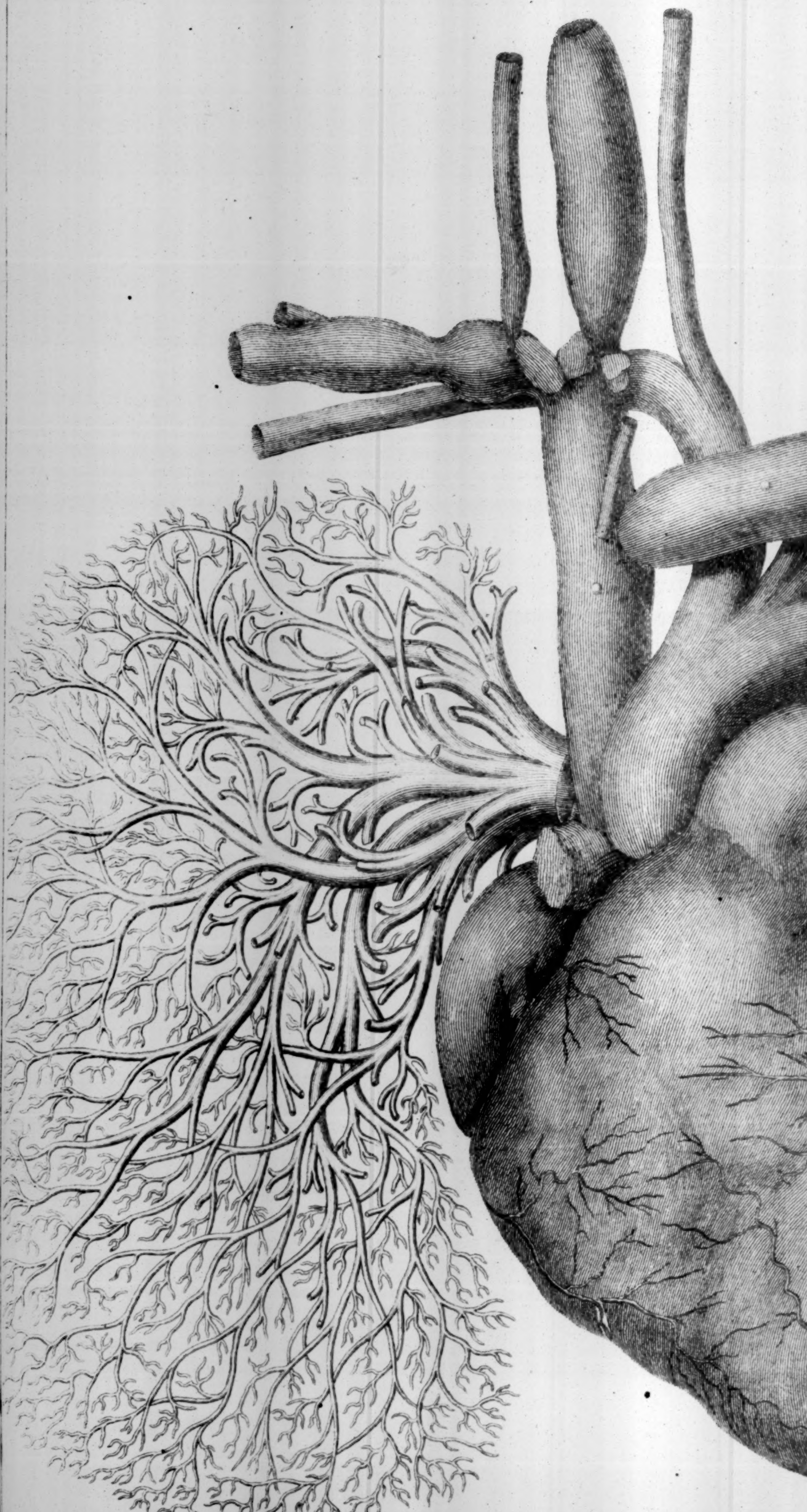
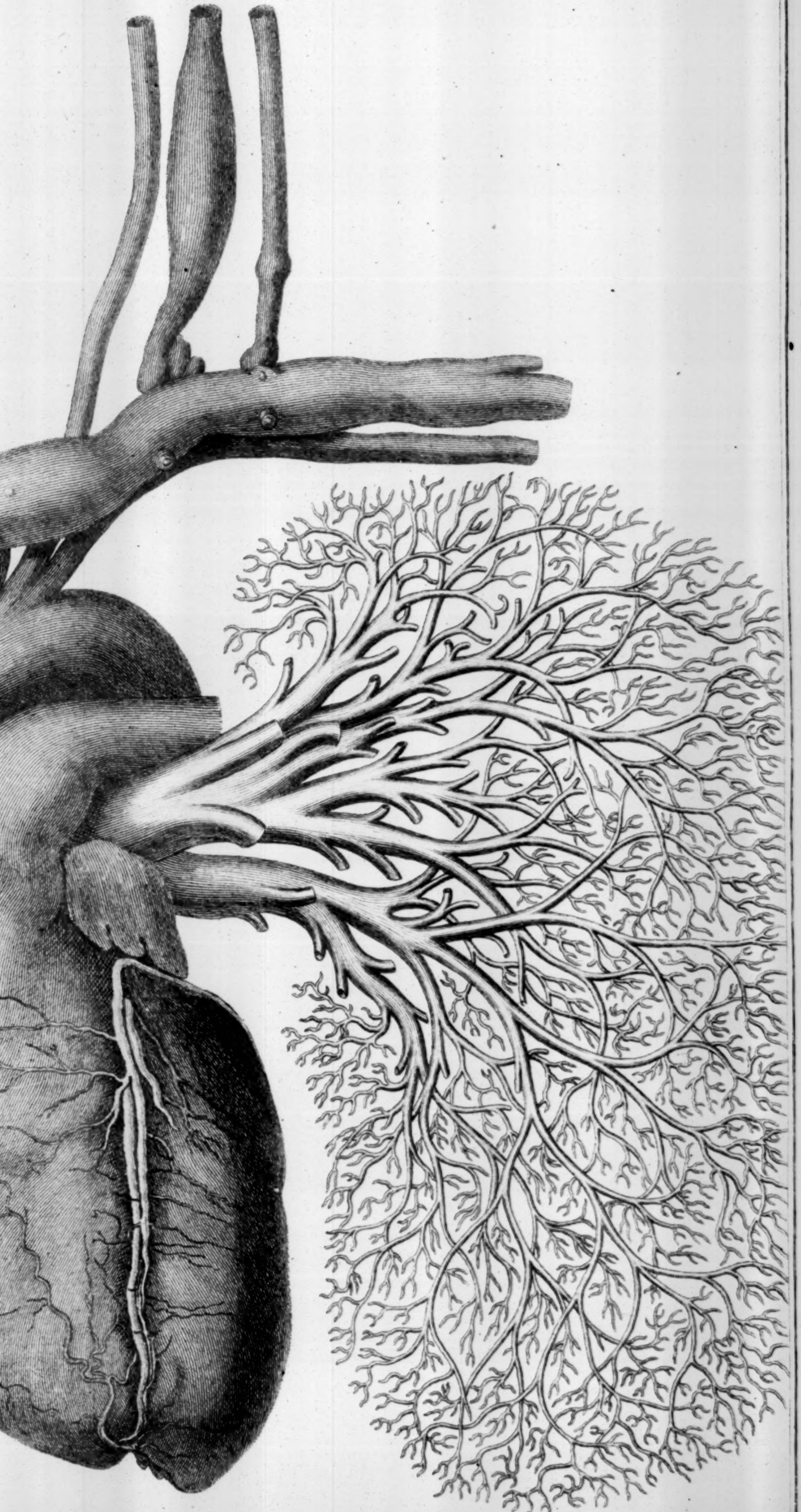
* Viz. the *two* VENÆ CAVÆ, and the *four* PULMONARY VEINS.

† Viz. the AORTA, and the PULMONARY ARTERY.

SECT.





SECT. VI.

ON THE PULSATION OF THE HEART AND ARTERIES AS DEPENDANT UPON VITAL AIR.

HINC quoque apparet ſanguinis *principalitas*, quod PULSUS *ex eo ortum ducat*. Nec ſanguis ſolum pars primigenia et principalis dicendus eſt, quod ab eo motus pulſuſque principium orietur; ſed etiam quia in eo primum CALOR ANIMALIS innaſcitur, SPIRITUS VITALIS ingeneratur, et ANIMA IPSA conſiſtit. HARV. Exer. 51.

Hence alſo appears the *pre-eminence* of the blood, that the *pulſation* of the HEART and ARTERIES owes *its origin* to it. Nor is the blood to be called the *firſt mover* and *pre-eminent* for this alone, but becauſe from it ſprings the VITAL HEAT, the ANIMAL SPIRITS, and LIFE ITSELF.

How infinitely near does the immortal HARVEY approach the truth, and yet, I believe, he had not the moſt *diſtant conception*, that OXYGEN AIR was the *principle* from whoſe *benign influence* all THESE WONDERFUL PHENOMENA ariſe.

It is the ſtudy of air, and aerial fluids, that has brought to light all the beautiful diſcoveries which modern phyſiology can boaſt of.—

In the laſt ſection it was ſhewn, how the blood was a fluid of a rich *vermilion colour* in the *arteries*, and of a ſtrong *purple colour* in the *veins*. When Dr. GOODWIN opened the thorax of a living dog, the lungs being collapſed, the heart ſoon ceaſed to play, the animal then languiſhed, and ſeemed expiring, but was revived again when *air* was blown into his lungs: then began again the motion of the heart; the blood receiving the ſtimulating influence of VITAL AIR, acted on the left ſide of the heart, and the right ſide moved in ſympathy *, and the circulation was excited anew, and life continued. Now, this change in the motion of the heart happening ſo plainly from acceſs of *air*, is a circumſtance of the moſt intereſting nature, and obliges us to look into the doctrines concerning chemiſtry for the ſolution of a phænomenon to which there is in the whole animal œconomy nothing to be compared.

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* The right ſide of the heart pulſates, although it receives only *venal blood*. To ſolve this difficulty we are obliged to uſe the word *ſympathy*; thus if the noſtrils be irritated, the muſcles of the diaphragm are thrown into ſpaſmodic action, and an irritation of the ſtomach brings into action all the abdominal muſcles. Thus a diſeaſe of the kidney is marked by a numbneſs along the thigh, a gall ſtone by vomiting, and a diſeaſe of the liver by pain on the ſcapula. Of the cauſe of this connection we are ignorant, and therefore are reluctantly obliged to have recourſe to the term *ſympathy*.

On this occaſion it is obvious to remark the *importance of the* LUNGS; we perceive that the blood, every time it is *returned* to the *right ventricle* of the *heart*, is directly diſperſed throughout *the lungs*, and *immediately reconveyed to the heart*, *before it is permitted to begin a new circulation*; I may add, before it is CAPABLE of performing a *new circulation:* for had there been no real neceſſity, we may boldly aſſert, this operation of the blood *paſſing from the right ſide of the heart through the lungs to the left* would never have taken place. In the ſtudy of nature, throughout all her works, however *complex* the machine, the *utility* of each part ever claims the admiration of the ſpeculative mind: this obſervation is beautifully illuſtrated on the preſent occaſion; and I believe it will be admitted by every one, that the blood, after having performed *one round* throughout the animal œconomy, undergoes ſome *new* and *important change*, in its *tranſit through the* LUNGS, eſſentially requiſite to ſupport a *ſecond circulation.* This change is certainly the *oxydation* of the blood, and we ſhould expect, if OXYGEN be the natural ſtimulus* to the heart and arteries, that their pulſation would be in proportion as the blood had acceſs to this principle. That this is the caſe, appears from the following experiment, made before a moſt reſpectable ſociety of gentlemen, who met once a week at Dr. HIGGINS' for the purpoſe of making philoſophical experiments. Although Mr. TAYLOR was not more than 22 years of age, his natural pulſe was only 64 previous to the experiment we are about to relate. During the inhalation of 19 pints of OXYGEN AIR, his pulſe, as Dr. HIGGINS remarked, was quickened to 90 *beats in a minute*, and was conſiderably increaſed in *fulneſs* and *ſtrength*. The veſſel being immediately charged again with 19 pints of pure OXYGEN GAS, he reſpired theſe alſo, and conſumed them entirely in ſix minutes. His pulſe was in conſequence increaſed to 120 *beats in a minute*, and was *vigorous withal*[*].

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* As a negative proof, we have thoſe experiments where perſons have breathed a reduced atmoſphere. One conſumptive patient, contrary to my judgment,

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judgment, ſays Dr. BEDDOES, uſed to inhale at times air wholly deprived of *oxygen*. During this proceſs I have felt the pulſe nearly "*obliterated*." He loved to indulge in it, and deſcribes the incipient inſenſibility produced on him as a ſtate highly delightful. Vide Dr. BEDDOES's *Obſervations*, p. 30.

[*] See *Minutes of the Society for Philoſophical Experiments*, p. 146.

SECT. VII.

ON ANIMAL HEAT AS DEPENDANT UPON VITAL AIR.

IT was ſhewn in the laſt ſection, that when the heart did not receive blood impregnated with *oxygen air* it ceaſed to beat; beſides *the circulation of the blood* we are indebted for our VITAL HEAT ALSO TO THE OXYGEN AIR CONTAINED WITHIN THE BLOOD.

The ingenious Dr. CRAWFORD appears to have been the firſt who attempted to aſcertain by direct experiments the cauſe of ANIMAL HEAT as dependant upon the air. In an elaborate work he maintains, that the blood, which is returned to the lungs, is highly charged with *phlogiſton*, — that the air having a greater affinity for *phlogiſton* than the blood, attracts to itſelf *that principle*, and having in conſequence a leſs *capacity* for heat than before, it parts with a portion of its heat, — and as the *capacity** of the blood for heat is at the ſame time increaſed by the ſeparation of the *phlogiſton*, the *heat*, detached from the air, is fixed in a quieſcent or latent ſtate in the blood:—and that the blood in the courſe of the circulations abſorbing *phlogiſton*, and thereby having its *capacity* for *heat* diminiſhed, part of it (in proportion to the quantity of *phlogiſton* abſorbed) breaks out in the form of ſenſible or moving heat, and hence the cauſe of ANIMAL HEAT.

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* The meaning of this word may be eaſily underſtood, if we contemplate the CAPACITY of a *ſpunge* for containing water, and that of any other body; it muſt appear that bulk for bulk, its CAPACITY with regard to that fluid, is greater than the CAPACITY of any other known ſubſtance. Or, to give another illuſtration, *hot water* will diſſolve a greater quantity of *ſalt* than *cold*, and

It required a ſtrong philoſophic conviction in Dr. THORNTON to depart from a propoſition at that time ſo generally received. But having made many expe-

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and *hot air* will ſuſpend a greater quantity of *moiſture* than *cold air*. Hence *when theſe are changed into each other*, that is, the *hot water* containing ſalts is *converted* into *cold water*, and the *hot air* of the day into the *cold air* of the evening: in the firſt inſtance, the *ſuperabundant ſalt* before held in ſolution will be depoſited at the bottom; and in the ſecond, the moiſture, or the *dew* of evening, will deſcend on the ground. In the ſame manner the CAPACITY for *heat* being found greater in *arterial* than *venous blood*; hence when the *arterial* becomes *venous blood* (juſt as the *hot air* converted into *cold air* depoſited its *moiſture*, and *hot water* converted into *cold* depoſited *its ſalt*), ſo muſt *arterial* blood converted into *venous* depoſit its ſuperabundant *heat*.

Dr. CRAWFORD's opinion therefore, to ſtate it in a few words, is, that, in *reſpiration*, the blood is *diſcharging* PHLOGISTON and *abſorbing* HEAT; and that *in the courſe of the circulation*, it is continually *imbibing* PHLOGISTON and *emitting* HEAT. This excellent philoſopher became, however, a convert to the *new* or *antiphlogiſtic chemiſtry*, and being a patient to Dr. THORNTON for the inhalation of air in a pulmonary complaint, he declared to that phyſician he was ſatisfied at the juſtneſs of his arguments adduced at Cambridge reſpecting the cauſe of *animal heat* as depending upon the decompoſition in the body of VITAL AIR.

riments, when inquiring into this ſubject, he was confident, that the OXYGEN AIR which WAS ABSORBED BY THE BLOOD (as is proved in Sect. VI.), was the true ſource of ANIMAL HEAT. Struck with the important diſcovery, he propoſed it as the ſubject of his *theſis* at CAMBRIDGE. The profeſſor of phyſic at firſt refuſed it, as being an opinion perfectly *novel*. He, however, at length very politely conſented to his diſputation on this queſtion, and Dr. THORNTON maintained at CAMBRIDGE, previous to his receiving his degree in phyſic in that univerſity, in oppoſition to the opinion of Dr. CRAWFORD, "that the "*venal* blood in the lungs abſorbs from the air not "*fire*, but *oxygen*, in combination with *the matter of heat* "(OXYGEN AIR), and that in the circuit of the blood "through the body, the *oxygen*, meeting with ſome ſu-"perior attraction, is divorced from its *caloric* *, which "becoming diſengaged *(juſt as an acid diſcovers its ſen-"ſible properties, its alkaline baſis being withdrawn from "it)*, ſo did it aſſume its well known *active* character; "and as *uncombined fire* ever tends to form an equilibri-"um, or equal temperature with the ſubſtances around,

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* The matter of heat.

" by pervading the body, it became the ſource of VITAL " or ANIMAL HEAT."

Animal heat, therefore, appears to be *a gentle combuſtion*;—and *an animal* in many reſpects may be compared to a *burning lamp*; the HEAT produced in both caſes ariſing from the *ſame cauſe*.

If AN ANIMAL be placed in *an exhauſted receiver* of an air-pump it quickly expires; in ſimilar circumſtances A BURNING LAMP goes out. If AN ANIMAL be not ſupplied with *freſh air* it dies, and its *heat* is extinguiſhed; ſo it is with THE LAMP. The air breathed by ANIMALS is *diminiſhed in quantity*; ſo it is by the burning of THE LAMP. A *certain quantity* of air ſupports AN ANIMAL for a *certain time*, but no longer; ſo it will keep up THE FLAME OF THE LAMP, for a *certain* time only. The air in which a LAMP has burnt out *deſtroys* ANIMAL *life*; ſo the air that THE ANIMAL hath breathed, *puts out* THE LAMP. Fixed, azotic, and inflammable airs, *deſtroy* ANIMALS; ſo likewiſe do they *extinguiſh* THE LAMP.

A LIVING ANIMAL and a BURNING LAMP, therefore, exactly agree in requiring the *ſame kind of air* to ſupport them, and in producing *the ſame effects* upon the air, to which they are expoſed.

But they do not reſemble each other only in *producing* HEAT, *and requiring the ſame kind* of AIR: for if AN ANIMAL hath not *freſh ſupplies* of FOOD, as well as AIR, after a *certain time* it dies, and becomes cold; juſt in the ſame manner as THE LAMP dies out, if not *duly ſupplied* with OIL.

Since then, *that part* of the air deſtroyed by RESPIRATION is the *ſame* as *that* deſtroyed by COMBUSTION: and ſince the *ultimate effect* is the *ſame* in both operations, that is, THE PRODUCTION OF HEAT, is it not reaſonable to think, that the FOOD affords to the ANIMAL *principles alike attractive of* OXYGEN, *and diſengaging* HEAT, as the OIL affords to THE LAMP? For ſince *the effects* are the ſame, *the cauſe* muſt be ſo too. OIL, therefore, *affords the principal attractive of* OXYGEN to THE LAMP: and, conſequently, THE FOOD of animals *ſupports the generation of heat*, by *ſupplying to the animal body thoſe principles which are attractive of* OXYGEN, *the baſe of vital air.*

The *chemical analyſis* of ſuch ſubſtances as are to ſupport animal life confirms this opinion; for no ſubſtance affords proper nouriſhment, which contains not principles that readily combine with OXYGEN; and the inſtantaneous ſupport, and refreſhment, perceived by thoſe, who are much exhauſted, upon taking into the ſtomach certain inflammable ſubſtances, as diluted ſpirits, &c. depend upon the ſame principle. *Very different matters*, therefore, will ſupport ANIMAL LIFE, if they contain principles, ſeparable by the animal proceſs, that have an affinity with *oxygen*.

To prove that *animal heat* ariſes from the *decompoſition* of VITAL AIR by thoſe ſubſtances which attract *oxygen*, we have the following very ſtriking facts.

Mr. WINDY having been previouſly indiſpoſed with ſtomach affection, had the extremities remarkably *cold*. He became at length inſane. He was placed in a madhouſe at Chelſea; where for the firſt five months he raved, and after that, for four months, he ſcarcely ever uttered a ſingle word. When he was removed from this place to be under Dr. THORNTON, he was gloomy, ſullen, and ſilent, or muttered only expreſſions, which evinced what were the terrors of his diſturbed imagination. He had no recollection of his wife or children, and the only notice he took of his attendants, was to manifeſt ſuſpicion that they meant to injure him. Dr. THORNTON gave him for ſome days *oxygen air* mixed with atmoſpheric daily, but his hands continued ſtill as cold as clay. *Ether*, *brandy*, and *wine*, were tried, but without the leaſt effect in warming him when employed alone: but the primæ viæ being cleared, and ether and brandy being given, before the inhalation and after, a general *glow* was immediately produced, which extended even to his fingers ends. Nor was this a tranſitory effect, for the benefit after a while became permanent*.

Dr. Beddoes, the juſtly celebrated profeſſor of chemiſtry at Oxford, reſpired at times for ſeven weeks air of a much higher than the ordinary ſtandard, and commonly ſuch as contained almoſt equal parts of oxygen and azotic airs. He relates, in his letter to Dr. Darwin, " that " he felt that agreeable *glow*, and lightneſs of the cheſt, " which has been deſcribed by Dr. Priestley and " others. In no long time," he ſays, " I obſerved in " myſelf a remarkable power of ſuſtaining *cold*. Except " one or two evenings I never once experienced the ſen- " ſation of *chillineſs*, though cold eaſterly winds prevail- " ed, during great part of the time I inſpired the *ſuper-* " *oxygenated air*. I was not only able," he adds, " to

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* For the ſequel of this caſe ſee the Section Melancholia, or Dr. Beddoes's Conſiderations, Part III. p. 109. It is thus with the culinary fire, ſometimes it will be ſufficient to *blow* it; added to this we muſt ſometimes employ *ſticks* alſo, and the fire being once well kindled, it will afterwards maintain itſelf.

“ reduce my bed-clothes to a ſingle blanket and coverlid, but ſlept without inconvenience in a large bed-chamber, looking to the north-eaſt, with the window open all night, and with the door and windows of an adjacent ſitting-room alſo open.—My appetite was keen, and I eat *one third* or *one fourth more than before,* without feeling the ſtomach loaded.

ANIMAL HEAT, THEREFORE, PROCEEDS FROM THE CHEMICAL UNION OF CERTAIN PARTS OF OUR FOOD AND OXYGEN, MODIFIED, AND COMBINED, BY THE PROPER EXERCISE OF THE NATURAL ANIMAL FUNCTIONS DISENGAGING CALORIC[*].

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[*] Vide Sect. X on the balance betwixt digeſtion and the *oxygenation* of the blood, where it is ſhewn how the *gaſtric juice* has a ſolvent power over *certain ſubſtances*. Our aliment is therefore broken down in the ſtomach into its conſtituent principles, and theſe comminuted parts then enter and paſs along the capillaries of the inteſtines, which are incapable of admitting any ſubſtance, unleſs in an highly attenuated or *aerial* form.

The anatomical lecturer at Piſa, in the year 1597, happening to hold a lighted candle near the ſubject he was diſſecting, on a ſudden the vapours that iſſued from the ſtomach and inteſtines were ſet on fire In the ſame year Dr. RUISCH was diſſecting a woman, and had no ſooner opened the ſtomach, than there iſſued out a yellow greeniſh flame, ſuppoſed to have ariſen from the vapours, which were kindled by a ſtudent's holding a lighted candle near him. Dr. VULPARE, the anatomical profeſſor at Bologna, affirms that any one may ſee, iſſuing from the ſtomach of an animal, a vapour that *burns like ſpirits of wine,* if the upper and lower orifices are bound faſt with a tight thread. The ſtomach thus tied, muſt be cut immediately under the upper ligature, the contents of the ſtomach being firſt preſſed with both hands, ſo as to paſs to one ſide. A candle being held about half an inch from the aperture, a flame will be obſerved immediately to iſſue from the ſtomach. BARTHOLINE relates the caſe of a perſon, who having drank much brandy for a wager, died, after an eruption of a flame of fire had firſt iſſued from his mouth. *The inflammable woman of Coventry*, as deſcribed by Mr. WILMER, appears alſo to have reduced herſelf by dram-drinking to ſuch a ſtate as to be capable of being ſet on fire, and burn like any very combuſtible matter; *ſo eager*, ſays the learned Dr. BEDDOES, *were the principles of which ſhe was compoſed to combine with oxygen.* In like manner the counteſs *Cornelia Bandi*, near Ceſena in Romagna, in 1731, in the ſixty-ſecond year of her age, was found in the middle of her bed-chamber reduced to aſhes. Theſe aſhes were light, and left in the hand a greaſy and ſticking moiſture. The floor was ſmeared with a groſs unpleaſant moiſture, and the walls and furniture were covered with a moiſt ſoot.

An inſtance of the ſame kind occurred at Chriſt-Church in Hampſhire, June 26, 1613. One John HITCHELL, a carpenter of that pariſh, a great drunkard, having ended his day's work, came home and went to bed. His wife found him dead before morning at her ſide. He felt ſo extremely hot, that it was impoſſible to touch him. *He lay burning for three days*; nor was there any appearance of flame outwardly, but only a ſmoke or miſt aſcending from his carcaſe till it was conſumed.

GRACE PETT, a fiſherman's wife, of the pariſh of St. Clement's, Ipſwich, about ſixty, was alſo conſumed by an internal fire. She appeared like a heap of charcoal, covered with white aſhes; the legs, arms, and thighs, were very much conſumed. However it is remarkable that the deal floor on which ſhe was extended had no appearance of being in the leaſt ſinged.

Theſe curious inſtances of *quick combuſtion* carried on in the body, if I may be allowed to continue the expreſſion, are adduced only as exceptions to Dr. THORNTON's general rule, "that within the body there is always carried "on a *gentle combuſtion*, productive of THE VITAL FLAME."

SECT. VIII.

HOW LIFE DEPENDS UPON A DUE QUANTITY OF ANIMAL HEAT.

In the laſt Section it was proved, that *vital heat aroſe from the decompoſition of oxygen air in the blood.* In this it will appear, HOW LIFE DEPENDS ON A CERTAIN DEGREE OF HEAT IN THE BODY.

In the chick contained within an egg there are no powers capable of generating heat. Therefore until the chick receives heat from the mother it remains in a torpid and inactive ſtate. The principles of life are then called into action. A gradual extenſion of the parts commence. During the time of incubation, the living principle every day increaſes in quantity and power with the perfection of the animal, and the capacity of its organs for performing its functions, and *generating heat*, which laſt does not happen till the time of its excluſion from the ſhell: after which, the chick does not depend *entirely* on the mother for the production of that heat, which muſt always accompany and ſupport the functions of life. When, by reſpiration, the firſt action after birth, *oxygen air* is abſorbed by the blood, the motion of the heart, the circulation, and other operations, are carried on with greater vigour than formerly, and the food being ſeparated into principles attractive of *oxygen*, the chick is capable, in a great meaſure, of generating a degree of heat equal to that of the parent. At firſt the mother, by a wonderful inſtinct, as if conſcious of the tender ſtate of her offspring, and of the impoſſibility of their being kept ſufficiently warm by their own powers, gathers them under her wings to cheriſh that vital warmth, which ſhe appears to judge them incapable of creating, and *without which* they would neceſſarily periſh. In the ſame way, if, during incubation, the hen leaves her neſt ſo long as to cool the eggs a few degrees, from that period the powers of life are proportionably diminiſhed, and a ſtop is put to the growth of the chick; both of which, if the eggs have not been cooled too far, are recoverable on the return of the hen, or of that genial heat they receive from her body. The mother is ſo ſolicitous to preſerve *this heat*, that ſhe ſeldom leaves her neſt above five or ſix minutes in the day, to take a ſlender repaſt; and when ſhe diſcovers the motion of the chickens in the eggs, ſhe then ſits ſo cloſe, that even the ſight of food, though ever ſo much preſſed by hunger, can ſcarcely prevail with her to ſtir from the eggs for three or four days, or until they are completely hatched. But if ſhe abandons her neſt altogether, or is killed by accident, then, as the eggs cool, the powers of life gradually decline, till they are at laſt totally aboliſhed by the death of the chickens.

Though the *functions of life*, in this inſtance, are ſoon deſtroyed or ſuſpended for want of a due quanquantity of animal heat, yet in ſome creatures, under theſe circumſtances, the *vital principle* ſtill remains entire. Thus flies, when the cold comes in, appear as if deprived of ſenſe, and in proportion to the degree of cold, the *moving mechaniſm* is *retarded.* But if the weather be *intenſely cold*, *they then* " *ſleep the* " *ſleep of death.*" Hence the reaſon why we ſee toads burrowing, frogs living under large ſtones, ſnails ſeeking ſhelter in the hollows of trees, and fiſhes having recourſe to deep waters; the heat of all theſe places being generally *above* the freezing point, even in our froſts, which are however ſometimes ſo ſevere, as to kill many whoſe habitations are not well choſen.

SECT. IX.

HOW NATURE INCREASES OR RIDS HERSELF OF THE ANIMAL HEAT.

IN the laſt Section *the connection between life and heat* was ſhewn; we ſhall ſlightly conſider here THE METHOD NATURE TAKES TO INCREASE OR RID HERSELF OF THIS SUBTILE AND PENETRATING FLUID.

ANIMAL HEAT USUALLY EXCEEDS THE SURROUNDING AIR.

As the heat of the living body generally *exceeds* that of the ſurrounding atmoſphere, it is obvious, ſo far from any heat being derived from it, on the contrary, the body muſt *communicate* heat to the external air; and if we conſider the great difference ſubſiſting between the temperature of the human body *, and that of the atmoſphere in our climate, it is clear that a very large portion of heat muſt be ever *eſcaping* from the body, and of courſe there muſt be *conſtant generation* of animal heat carried on in the body to balance this conſumption.

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* A thermometer being put under the tongue of man in all countries *riſes* to 97. HUNTER *on the Animal Ecomomy*.

Every one who has paid attention to the temperature of the atmoſphere by means of the thermometer, muſt have obſerved how frequently our feelings, reſpecting heat and cold, *diſagree* with the indications of them, as expreſſed by that inſtrument; ſince it often happens, that when experiencing a very conſiderable degree of cold, we are ſurpriſed to find the mercury at a moderate temperature; and this may be obſerved uſually to happen in *windy weather*, or when the air is particularly loaded with *wet particles*.

This can be accounted for on no other principle than that of *the conſtant production of heat within the animal, and of its tendency to paſs off by the ſurface:* for the thermometer very ſoon acquiring the temperature of the air, becomes at once ſtationary, varying only with the real changes which take place in the atmoſphere; whereas the conſtant ſucceſſion of heat, which there is in the living animal, prevents its acquiring the temperature of the air, and it cannot, therefore, like the mercury, deſcend to its temperature, and then become ſtationary; and as the ſenſe of cold felt by us, muſt conſequently be owing to the conſtant *eſcape* of heat which is thus promoted, the degree of cold felt muſt obviouſly be in proportion to the celerity with which the air is enabled to *carry off* the warm atmoſphere ſurrounding us.

The effects produced by *fanning*, when perſons are very hot, may be underſtood from the principles of the foregoing doctrine: when the ſurface is loaded with heat, and the air, which is in immediate contact with it, has already taken up ſo much, that it is either unable to carry off any more, or performs this office ſo ſlowly, as to be unequal to the removal of the quantity which is conſtantly arriving at the ſurface, the driving away ſuch air by the fan, and permitting other colder air to approach, which not being ſo loaded, is able to carry off the heat more quickly, the ſkin muſt in conſequence feel cooled.

Moiſt air is, likewiſe, a better conductor of heat than when dry, becauſe *water*, though of the ſame temperature with air, is well known to carry it off more quickly than air will do.

If, therefore, *theſe two cauſes unite*, as is the caſe in *moiſt* and *windy* weather, we may eaſily underſtand why the heat from animals ſhould be carried off more quickly, and the animals ſhould experience a greater ſenſe of cold, than when the air is *ſtill* and *dry*, though the thermometer ſhould, in both caſes, ſtand at the ſame point.

Even in torpid animals the temperature of heat is conſtantly *higher* than the ſurrounding medium.

In the *winter*, the atmoſphere at forty-four degrees, the heat of the torpid hedge-hog at the diaphragm was found, by Mr. JENNER, to be 48°½.

When the atmoſphere was at twenty-ſix degrees, the heat of a torpid hedge-hog was reduced ſo low as 30°.

In *ſummer*, the atmoſphere at ſeventy-eight degrees, the heat of the hedge-hog at the diaphragm was found to be 97°.

The atmoſphere being at thirty, that ingenious and moſt accurate experimental philoſopher, Dr. HAIGHTON, the preſent Lecturer on Phyſiology at GUY's Hoſpital, found the animal heat of a torpid bat at 33°; and when the atmoſphere was at ſixty, he found it ſo high as 63°; that is, during life the *vital heat* was always found, even in dormant animals, to exceed the ſurrounding medium.

I. OF THE RETENTION OF ANIMAL HEAT.

It may be remarked, that all animals, when the heat is paſſing off them in an *inconvenient degree*, endeavour to CHECK IT by leſſening the ſurface of their bodies, which is expoſed to the ſurrounding air; thus we ſee why dogs, cats, &c. when lying on the ground, and not in a warm ſituation, draw their limbs cloſe to them, and endeavour to acquire ſuch a poſture of the whole body, as ſhall bring all the parts as much into contact as poſſible; and when in a contrary ſituation, as expoſed to the warm rays of the ſun, or near the fire, they ſtretch out their limbs, and extend their whole ſurface as much as poſſible: and we all know, that we ourſelves, when naked, or when entering a cold bed, do exactly the ſame thing; and in bed we continue ſuch a poſture until ſuch a quantity of heat has been accumulated, and confined by the bed-clothes, as to remove all ſenſation of cold, when, like the before-mentioned animals, we ſtretch forth our limbs, and acquire our accuſtomed poſture.

The univerſal cuſtom of the inhabitants of all countries in which the temperature of the atmoſphere is below

low the ſtandard of the heat of the human body, making uſe of apparel, and this being thicker or thinner in proportion to the reſpective differences of ſeaſons or climates, is founded on the ſame principle, *to prevent ſuch an eſcape of heat from the body as would be unpleaſant or injurious.*

The ſame thing may be obſerved of the natural clothing of different animals; in *warm climates* their coats are ſhort, ſmooth, and lie cloſe to the ſkin; but in the *northern regions* their covering conſiſts of a rarer ſubſtance, as fur, wool, &c.

It may likewiſe be obſerved, that even in the *ſame animals* a difference, reſpecting the heat-conducting powers of their covering, takes place under different expoſures; that in *ſummer* it is leſs calculated to retain their heat than in *winter*, and when protected by the external cold, by living *within doors*, than when expoſed to it when living in the *open air*. The horſe may be conſidered as a very familiar inſtance of the truth of this remark, for every one knows how long and rough the coats of thoſe are which winter in the *ſtraw-yard*, and how ſhort and ſmooth are the coats of thoſe which are kept in warm *ſtables*; and that it is a common practice with ſuch as have the care of horſes, to cover them with woollen cloths, to render their coats fine and ſmooth.

In *birds* this provident care of nature is peculiarly ſtriking; as they paſs freely through the air, and are often expoſed in the higher regions to a very cold medium, their natural heat would paſs off much too quickly, if they were not covered with a ſubſtance which conducts heat very ſlowly, which feathers are well known to do: and in thoſe birds which *live in water*, which withdraws heat much quicker than air, their covering is much more rare and compact than common feathers; the down upon the breaſt and under the bellies of thoſe birds, which in cold climates live principally in the water, being perhaps the ſloweſt conductors of heat in nature; modern luxury having, on this principle, ſet a great value on the down of the *cider duck*, and its uſe in retaining heat, to which it is applied, being well known in fits of the gout; to which caſes, on account of its extraordinary lightneſs, it is particularly well adapted, as the parts affected are uſually ſo exquiſitely tender, as to ſuffer pain from the contact of whatever has weight, or occaſions preſſure. The ſlow conducting power of this down being evidently owing to its rare texture, it is obvious, that to retain this quality it ſhould remain perfectly dry, as the plumage, when *wet* *, will very ſoon collapſe together, and form a body capable of carrying heat off, perhaps, too quickly. To guard againſt this circumſtance, nature has kindly furniſhed *theſe aquatic birds* with a peculiar kind of OIL, and has given them the power of occaſionally opening the receptacle where it is depoſited, and of ſpreading a ſufficient quantity of it over their outermoſt feathers, by which the contact of water is effectually prevented.

Laſtly, we may obſerve, that the *ſenſible perſpiration* is much leſs in cold than in hot weather, which circumſtance in the next paragraph will be more particularly conſidered.

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* Mr. HUNTER, having put a *dormouſe* in a freezing mixture, could not freeze the whole animal, but only the feet, the hair being ſo bad a conductor of heat, that the *heat* withdrawn from the animal was not more than its powers were capable of generating. Taught by the failure of this experiment, I took care, ſays this great phyſiologiſt, that the hair ſhould not a ſecond time be an obſtruction to our ſucceſs. Having, therefore, firſt made the animal *wet all over*, that its heat might be more expeditiouſly carried off, it was put into a leaden veſſel, and the whole placed in the cold mixture as before. The animal ſoon gave ſigns of feeling the cold, by coiling itſelf into a round form, and repeatedly attempting to make its eſcape; and the breath and water evaporating from its body being ſoon frozen, appeared like a hoar froſt on the ſides of the veſſel, and on its whiſkers; but as long as the vigour of life laſted, it ſeemed to defy the cold. However, from the hair being *wet*, and thereby rendered a good conductor, there was a much greater conſumption of heat than in the firſt experiment; which haſtened on a diminution of the power of producing it. The animal ſoon became ſtiff; and upon being thawed, was found quite dead. HUNTER *on the Animal Economy*.

II. THE ESCAPE OF ANIMAL HEAT.

When the air is of that particular temperature which, with the aſſiſtance of other operations in the œconomy, is juſt ſufficient to carry off ſuch a quantity of the heat generated in the body, that the remainder ſhall exactly ſupport the animal body, we ſay ſuch an air is mild, or it is temperate; becauſe we are not ſenſible of any troubleſome degree of heat or cold. This preciſe temperature varies in different people, according to the climate, age, and conſtitution of the individual; but at whatever point of the thermometer this temperature may be, if it riſes or falls a few degrees only, we then complain of heat or of cold, and employ various ways of obviating their effects. When we are ſurrounded with a *warm air*, a *free perſpiration* ſucceeds; and if a further accumulation of heat takes place in the body, a *ſweat* is brought on proportioned to the ſtimulus, from the exceſs of heat. Nature is now employed in COUNTERACTING *the effects of an accumulation of heat* by the refrigerating proceſs of *ſweating*, and the conſequent expenditure of heat in the formation of vapour. How ſoon will the mercury and the thermometer cool by the ball being wet with æther, or volatile alkali? The degree of cold that may be produced in this way, has been ſufficiently proved by the celebrated Dr. CULLEN. Witneſs the ice found in the morning on linen hung out to dry during the night, when the temperature of the air is even much above the freezing point: the practice of cooling wine in warm countries, by hanging up their bottles in wet cloths to the ſun *, to expedite the evaporation; the cooling of the wine going on in proportion to the quickneſs with which its heat is abſtracted by the vapour. I ſhould not have inſiſted ſo much on the effects of *evaporation*, ſays Dr. GARDINER, Preſident of the Royal College of Phyſicians at Edinburgh, had I not conſidered it as a material circumſtance in examining the effects of hot air on the human body, which ſooner or later, according to the degree of heat it poſſeſſes, produces, in the manner above mentioned, a *ſweat*, and conſequently *evaporation* from every part of the body.

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* The Arabians have this remarkable method of cooling their wines when conducting caravans over the deſerts, which exhibits, in the moſt forcible manner, the truth of the above account. They dig a hole, and having filled it with ſtraw, they place the bottle of wine they mean to cool into the midſt of it, having previouſly ſurrounded it with *wet* ſtraw or clay. They then ſet fire to the ſtraw, and the bottle of wine is brought out (from the evaporation of the wet clay or ſtraw ſurrounding it) *quite cool*. Vide Philoſ. Tranſ. Vol. LXV. p. 252.

Not that the whole of the matter perſpired is turned into vapour; it is only ſuch a portion of it as can readily abſorb the neceſſary quantity of heat from the body and external air, which will be in proportion to the degree of heat they poſſeſs; the reſt running in drops off the body, or it is abſorbed by the cloths, and is afterwards evaporated from them.

The matter of heat, or caloric, finds, moreover, other outlets to eſcape by, beſides the ſurface of the body; as a conſiderable quantity muſt, evidently, paſs off from the *lungs* in breathing. Indeed the quantity which is carried off by the air and returned by the lungs, is found, by experience, to be much greater than one would at firſt imagine, "*for we know that the heat contained in one breath of air, will, if properly managed, raiſe Fahrenheit's thermometer ten degrees* [*]." And provident nature ſeems to take advantage of this circumſtance, when an extraordinary quantity of heat is ſuddenly excited in thoſe animals, which are but little able to carry off a ſuperabundance: thus *dogs*, which do not ſweat, and *ſheep*, whoſe clothing is ſo particularly unfavourable to the carrying off an unuſual quantity of heat, always open their mouths very wide, that the whole ſurface of the fauces may be expoſed, and move the tongue remarkably quick, to agitate the air in contact with it.

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[*] Vide Critical Review for January 1782, page 6.

When heat is accumulated in the ſyſtem, either by fever, by ſtrong exerciſe, or by the ſcorching heat of the ſun, nature conſtantly cries aloud for ACIDS, and a *cooling diet*; and to thoſe who have turned their mind to chemiſtry, the reaſon for this ſtrong deſire is obvious. They know that *animal heat* originates in the decompoſition of OXYGEN AIR, after it is received into the blood by the lungs; and they obſerve, that the quantity of air which is decompoſed or vitiated, bears direct proportion (as will be explained when mentioning the experience of the celebrated diver Mr. SPALDING*) to the quantity of combuſtible matter, whether animal or vegetable, whether ſugar, oil, or ſpirit, received into the ſtomach. They obſerve, likewiſe, that *acids* taken into the ſtomach always check and reſtrain the generation of heat; or, in other words, that when the ſyſtem is ſaturated with OXYGEN only, leſs OXYGEN AIR (oxygen and *caloric*) is imbibed by the blood in the lungs, and conſequently leſs *heat* will be evolved in the body. It is upon theſe principles, ſays the Rev. Mr. TOWNSEND, that the reapers in the ſouth of Spain covet their *guzpacho*, compoſed of bread, oil, and *vinegar:* the two firſt articles for nutriment, and the latter to moderate their vital heat. On the ſame principles, obedient to the voice of nature, during the ſultry heats of ſummer, we equally deſire our lettuce, oil, and *vinegar*, and we may remark, that in *warm climates*, and in ſummer in the *more temperate regions* of the globe, the *aceſcent* and watery fruits abound, but in the autumn *we* have chiefly thoſe which produce *oil* and *ſugar*, while dried *fiſh*, *meat*, and train *oil*, form the principal ſupport of the hardy inhabitants of the *north**.

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* Vide p. 111.

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* This ſubject will be more particularly conſidered when we come to deſcant *on the Nature and Treatment of Diſeaſes*.

SECT. X.

ON THE BALANCE BETWIXT DIGESTION AND THE OXYGENATION OF THE BLOOD.

I HAVE had, ſays the celebrated Spaniſh traveller the Rev. Mr. TOWNSEND, frequent opportunities of remarking a beautiful balance betwixt RESPIRATION and DIGESTION.

During a putrid fever, which attacked him laſt ſummer, it was too evident to eſcape the obſervation even of his *nurſes*. WHEN THE STOMACH WAS OPPRESSED, RESPIRATION LABOURED; AND WHEN THE LUNGS WERE PLENTIFULLY SUPPLIED WITH VITAL AIR, THE BREATHING BECAME EASY, AND THE SUPERABUNDANT QUANTITY OF FOOD WAS NO LONGER A BURTHEN.

Mr. TOWNSEND's words are*, " whenever the air of " my bed-chamber was artificially *oxygenated*, as my " phyſician Dr. THORNTON often witneſſed, *my re-* " *ſpiration was pleaſant, my oppreſſion at my cheſt relieved,* " *and I was enabled to breathe freely through the noſtrils* " *without the aſſiſtance of my mouth, which I could not do* " *before the room was oxygenated.* At the ſame time I

" am

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[*] Vide *the Guide to Health.*

“ am convinced THAT MY APPETITE WAS GREATLY “ INCREASED, AND MY DIGESTION CONSIDERABLY “ QUICKENED.”

The celebrated Dr. INGENHOUSZ obſerves, that the air at *Vienna* contains more OXYGEN than in the low country of *Holland*; HENCE THE INCREASE OF APPETITE OF THOSE WHO GO FROM HOLLAND TO VIENNA, AND THE REVERSE EFFECT WITH TRAVELLERS TO HOLLAND.

Dr. WITHERING writing to Dr. BEDDOES ſays, the experiments you wiſh for have been in part made. The late ingenious Mr. SPALDING, who did ſo much in improving and uſing the diving-bell, and had practiſed with the greateſt ſucceſs for many years, was a man of nice obſervation, and had he not fallen a ſacrifice to the negligence of drunken attendants*, would have thrown much additional light upon more than one branch of ſcience.

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* Mr. SPALDING twice went down, accompanied by a young man, who was educated by him, to view the wreck of the IMPERIAL Eaſt Indiaman on the coaſt of Ireland. On deſcending the third time, in June 1783, they remained above an hour under water, and had barrels of air ſent down to them, but not ſufficient for their wants, probably from the drunkenneſs of their attendants, hence they were both found dead in the bell. This unhappy event, ſays the celebrated Dr. DARWIN, may for a time check the ardor of adventurers in traverſing the bottom of the ocean, but it is probable in another half century it may be as ſafe to travel *under* the ocean, as *over* it, ſince Dr. PRIESTLEY's diſcovery of procuring VITAL AIR in the greateſt abundance from the calces of metals, as well as nitre.

He particularly informed me, "THAT WHEN HE HAD "EATEN ANIMAL FOOD, OR DRANK FERMENTED "LIQUORS, HE CONSUMED THE AIR IN THE BELL "MUCH FASTER THAN WHEN HE LIVED UPON "VEGETABLE FOOD AND DRANK ONLY WATER." Many repeated trials had ſo convinced him of this, that he conſtantly abſtained from the *former diet* whilſt engaged in diving.

We now ſee the reaſon why men who are oppreſſed with food, more eſpecially animal food, *pant*; and why in a cloſe room, where they are confined within the curtains of a bed, where the air is vitiated by paſſing frequently through their lungs, they open their mouths wide to breathe, and therefore why they *ſnore*.

I have often had opportunity to converſe with miners in Cornwall, Mr. TOWNSEND relates, who had been almoſt deprived of life by breathing a mephitic air, and have been informed by them, that on reviving they have conſtantly been ſeized with *nauſea*, and that commonly the ſtomach has rejected its contents quite *crude*.

Whenever the imperfect tribe of animals, or ſuch as ſleep out the winter, are expoſed to a cold ſo great as, in a great meaſure, to rob them of their *inbred heat*, their powers of *motion* are proportionably diminiſhed, and as they cannot have, at that ſeaſon, a very copious generation of caloric, but only enough to keep up the ſpark of life (their animal oil, which is compoſed of principles attractive of *oxygen*, being ſufficient for that purpoſe), they loſe all the power of *digeſtion*.

At Belliſle, in the beginning of the winter 1761, I conveyed, ſays JOHN HUNTER, worms, and pieces of meat, down the throats of lizards when they were going into winter quarters, keeping them afterwards in a cool place. On opening them at different periods, I always found the ſubſtances which I had introduced entire, and without *any the leaſt alteration*.

A hedge-hog, while the heat of the body was at 30 degrees, had neither *deſire for food*, nor power of *digeſting it*; but when by artificial means it was increaſed to 93 degrees, the animal ſeized a toad which happened to be in the room; and upon being offered ſome bread and milk, it immediately eat it. The heat rouſed up the actions of the animal œconomy; the breathing became quickened; and the blood, having imbibed a greater quantity of OXYGEN AIR, containing latent fire, to be extricated by the principles ſeparated by the ſtomach; hence the immediate call on the *digeſtive powers* of that organ.

SECT. XI.

ON STIMULI:

OR THE CAUSE OF MOTION
IN THE
VITAL, OR INVOLUNTARY, ORGANS.

IT was obſerved before, that the HEART was the center of motion, diſtributing and receiving the blood from every part of the body; or, to uſe other language, the *arteries* and *veins* reſemble diſtinct trees, whoſe *branches* inoſculate at top, and whoſe *trunks* are fixed in the heart, as the common baſis. The *nervous ſyſtem* may, in like manner, be compared to a tree, whoſe root is from the BRAIN, and whoſe *ſtem* is confined within the ſpine*.

From ſome experiments that have been made on *nerves*, it appears, that they do not ſhorten their dimenſions

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* The *brain* and *ſpinal marrow*, improperly ſo called, ſend off ſmall portions of their ſubſtance, ſurrounded by a part of their membranes. *Theſe portions* are called NERVES, of which 10 pair iſſue from the *brain itſelf*, and 30 pair from the *ſpinal marrow*; and theſe 80 nerves, divided and ſubdivided into an almoſt infinite number of ſmall cords, are diſtributed to every point of the body.—Dr. ADAIR.

ſions when excited by any ſtimulus, nor retract their divided parts when cut aſunder. They therefore eſſentially *differ* from that part of the animal fabric, which we call the CONTRACTILE LIVING FIBRE. *Theſe elaſtic threads* obey the impulſe of *different ſtimuli.* They are productive of motion in animals, as well as in the ſenſitive plant, and therefore act independent of nerves. They are diſpoſed, by the infinite wiſdom of provident NATURE, in different directions, ſo that when excited into movement, they may perform ſome important action.

The contraction of the HEART and ARTERIES, for the purpoſe of circulating the fluids, nouriſhing the body, and diſtributing the animal heat, is performed by means of *theſe contractile living fibres.* Thus an ARTERY reſembles, in ſome meaſure, a tube of living *elaſtic gum*, which when diſtended returns to its ordinary ſhape, and as *this elaſtic* and *irritable power* ſurvives * the life of the animal, arteries were believed by the ancients to be *air-carriers*, from which ſuppoſed office they derive their preſent name.

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* This *elaſtic principle* in the arteries acts ſo powerfully after death, that theſe tubes are conſtantly found void of blood. The ſame *elaſtic principle* in the muſcles renders the dead body, which was before pliant, tenſe and rigid. The barbarous cuſtom of hardening the fleſh of the cod, by *crimping* the fiſh alive, is another clear exhibition of the *great contractility* of the contractile living fibre.

The moving fibres of the HEART and ARTERIES are excited into action by the *quantity* of the blood, and the *ſtimulus* of OXYGEN AIR[*]. The contractile fibres of the STOMACH are excited into action by the *quantity* and *quality* of the food, or, in defect of theſe, by its own *gaſtric juice*; and the INTESTINES perform their periſtaltic or vermiform motion, by the excitement of the *bile* and their *natural contents*[†].

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[*] This poſition was before proved in page 75, from the celebrated experiment of Dr. GOODWIN. Another ſtrong proof *that oxygen air imbibed by the blood is an excitement to the heart and arterial ſyſtem*, may be ſeen among the records of the experiments of the Philoſophic Society at Dr. HIGGINS's. A YOUNG GENTLEMAN HAVING BREATHED PURE UNDILUTED OXYGEN AIR FOR SEVERAL MINUTES, HIS PULSE, WHICH BEFORE THE EXPERIMENT WAS AT 64, SOON ROSE TO 120 BEATS IN A MINUTE. Vide Sect. VI. *On the Pulſation of the Heart and Arteries as dependant upon Oxygen Air.*

What advantage may be derived to the ſick by increaſing or diminiſhing at pleaſure this *natural ſtimulus* in the blood may be eaſily conceived! Already much has been done, vide the Communications of Dr. THORNTON, &c. to Dr. BEDDOES. The celebrated Dr. WITHERING ſays, that the vital air when inhaled is a ſtimulus which produces *action* without *exhauſtion*, differing in this from all other ſtimuli.

[†] The ſenſibility of the contractile fibres varies greatly. Thus the *bile*, which is the natural purge or ſtimulus to the fibres of the bowels, when thrown back into the vaſcular ſyſtem, has very little effect upon it. Thus what paſſes *quietly* through the ſtomach is often a cauſe of great *irritation* in the inteſtinal canal. Thus the *gentle ſtimulus* of light is a *very powerful* operator in contracting the dimenſions of the pupil of the eye: i. e. occaſioning the reaction of its fibres.

Theſe moving fibres are alſo affected by *other* than their *natural ſtimuli*, which ſtimuli often appear to have a peculiar determination or action on a particular organ. Thus if *ipecacuanha* be injected into a vein, it excites the ſtomach, equally as though it had been taken by the mouth; and the ſame is the effect of *jalap*, or any other purgative, it will be conſtantly found to ruffle the inteſtines *. Thus, if *mercury* be oxydated, that is, combined with oxygen, the abſorbents † will convey it into the

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* A plaiſter of arſenic applied to a ſcald head, has been known to kill ſuddenly; I have ſeen convulſions and death from a quickſilver girdle applied to cure the itch. A decoction of tobacco uſed in waſhing the head, brought on vomiting, delirium, and convulſions: a poultice of this plant applied to the region of the ſtomach, produced vomiting, purging, and delirium: white lead applied to cure a ſcurfy eruption, brought on ſhortneſs of breath, vomiting, and fainting. In all theſe inſtances the miſchief was done by *uninſtructed old women*, and equally ignorant and *impudent quacks*; for when ſuch applications are made with *learning* and *judgment*, they are equally ſafe and effectual. Thus a bitter poultice applied to the belly deſtroys worms; flannels dipped in hot brandy allay vomiting; and opium applied externally mitigates pain; in one caſe, however, it produced, from the ignorance of the adviſer, convulſions and death. Thus ſeveral children have had their agues cured by a waiſtcoat of bark. At Guadaloupe, a phyſician, not long ago, by infuſing certain remedies into the veins, is ſaid to have cured ſeveral perſons labouring under inveterate diſeaſes, and the expedient ſeems to merit the attention of practitioners, eſpecially as we are aſſured that alarming ſymptoms from the bite of a viper were removed by injections into the blood.—Dr. Adair.

† I think I have proved, ſays the illuſtrious Dr. Hunter, that the lymphatic veſſels are the abſorbing veſſels, all over the body; that they are

the blood, and a decompoſition taking place, the metal will be *revived*, as is proved by its effects on watches, &c. and the *ſeparated oxygen* will become a powerful ſtimulus

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the ſame as the lacteals; and that theſe altogether, with the thoracic duct, conſtitute *one great* and *general ſyſtem*, diſperſed through the whole body for abſorption; that this ſyſtem *only* does abſorb; that it ſerves to take up, and convey, whatever is *to make*, or *to be again mixed with the blood*, from the inteſtinal canal, from the ſkin, and from all the internal cavities and ſurfaces whatever. In our times, after ſchools of anatomy have long flouriſhed in all the civilized nations of Europe, and when, from the number of men who have been employed in ſuch reſearches, it might have been imagined that diſcoveries were exhauſted, PROVIDENCE has allowed me a greater ſhare of that ſort of honour, than at firſt I could have expected. My diſcovery of the ABSORBENT SYSTEM gains credit daily, both at home and abroad, to ſuch a degree, that I believe we may now ſay, that it is almoſt univerſally adopted: and, if we miſtake not, in *a proper time*, it will be allowed to be the *greateſt diſcovery*, both in *phyſiology* and in *pathology*, that anatomy has ſuggeſted, ſince the diſcovery of the circulation of the blood.

Having ventured to throw out, continues Dr. HUNTER, ſo bold a propoſition, that my reputation may not ſuffer through want of a little reflection upon the ſubject, I muſt beg leave to explain my opinion. The diſcovery of a duct of a gland, an undeſcribed muſcle, an artery, or a concealed vein, all ſuch diſcoveries certainly are trifling, when compared with the introduction of a *new* and *general ſyſtem*, which is interwoven with, and performs a peculiar and important function in, every part of the body; ſo *important*, indeed, that it was neceſſary, and accordingly has ſince actually been found out in brutes, likewiſe in birds, and in fiſh. *Such is the diſcovery* of the ABSORBENT SYSTEM: and every perſon, who is really an anatomiſt, or phyſiologiſt, will, upon a little reflection, admit what has been here advanced; and, looking over the whole progreſs of anatomy, he will allow, that ſince the time of Ariſtotle to the preſent day, there have been only *two great diſcoveries* with regard to the phyſiology of our bodies; to wit, the VASCULAR SYSTEM, and the ABSORBENT SYSTEM, the BRAIN and NERVOUS SYSTEM having been long before known. Vide Dr. HUNTER's Second Lecture.

to the ſecreting organs, the abſorbents, and to the heart and arterial ſyſtem, but more eſpecially the ſalivary glands.

The vital organs, the heart, the lungs, the ſtomach, and inteſtines, which feel and react on their own peculiar ſtimuli, have, however, their appropriate and diſtinct NERVES*; ſo that our *mechanical ſyſtem* is not wholly unconnected with the *ſentient*; and hence the digeſtion, the action of the heart, the breathing, the vermiform motion of the inteſtines, are " languid and depreſſed," or fly into " angry and perturbed motions," whenever we are rouſed by violent and inordinate paſſions†.

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* The *phrenic nerve* goes to the diaphragm, or great muſcle of reſpiration, the *par vagum* to the ſtomach and bowels, and the *ſympathetic nerve* to the heart. Theſe nerves are much ſmaller and fewer than what go to the organs of voluntary motion.

† If a nerve be cut, leading to any of the vital organs, death enſues from the defective energy of that organ. The connection is therefore intimate between the *nerves* and the actions of the *contractile fibre*, but this is no argument that theſe are one and the ſame thing, as the *latter* appears to be governed by the ſame laws as act the fibres of the *ſenſitive plant*, &c. Vide Section on the Office of the Ganglions, Vol. IV.

SECT.

SECT. XII.

ON ANIMAL ELECTRICITY;

OR THE CAUSE OF MOTION IN THE VOLUNTARY ORGANS, OR MUSCLES.

DOES there appear any principle in all nature, ſays our Engliſh hiſtorian, more myſterious than the union of ſoul and body, by which the ſpiritual part poſſeſſes ſuch an influence over the material, that it is able to direct the motion of any muſcle, or even ſometimes a part of a muſcle. Were we empowered by a ſecret wiſh to diſplace mountains, or control the planets in their orbit; this extenſive authority would not ſeem more extraordinary or more unaccountable*. An accident fortunate for philoſophy has thrown, however, ſome light on this hitherto myſterious ſubject.

Whilſt Profeſſor GALVANI, at *Bologna*, was diſſecting a frog, in a room where ſome of his friends were amuſing themſelves with an electrical machine, one of them happened to draw a ſpark from the conductor, as the profeſſor touched one of the nerves of the animal. In an inſtant the whole body of the frog was ſhook by a violent convulſion.

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* Vide HUME's *Eſſays.* The ſame obſervation, in nearly the ſame expreſſions, may be found in VOLTAIRE's *Ignorant Philoſopher.*

The profeſſor was aſtoniſhed at the phenomenon, and believing it to be owing to his having wounded the nerve; to aſſure himſelf, whether this was really the caſe, he pricked it with the point of his knife, without any motion being produced: he now touched the nerve with the inſtrument as at firſt, and deſired a ſpark to be taken from the machine, on which the contractions were renewed.

The experiment was repeated a third time, but the animal remained motionleſs; however, as the ivory handle of the diſſecting knife was a bad conductor of electricity, he changed it for a metallic one, and re-excited the movements, which he conſtantly failed in doing whilſt uſing an electric ſubſtance.

After having made a great number of experiments with the electrical machine, he reſolved next to make trial of atmoſpheric electricity. To this end he raiſed a conductor upon the roof of his houſe, from which he brought an iron wire into his room, and to this attached metal conductors, connected with the nerves of the animals deſtined to be the ſubject of his experiments, and to their legs he tied wires, which reached the floor. Conſiderable movements were obſerved in the animals, whenever it lightened. Theſe preceded the claps of thunder, and always correſponded with their intenſity and repetition; and even when it did not lighten, the movements took place, whenever any thunder cloud paſſed over his houſe.

Having next laid bare the nerve leading to the wing of a duck, the ſciſſars of the operator being under it, whenever any of the company preſent applied a ſhilling, or a half crown, to the nerve ſo diſpoſed, the nerve was agitated by a violent movement, which occurred as often as the ſhilling or half-crown was employed, till the nerve was exhauſted of its power, which happened commonly in about 15 minutes.

It was afterwards found, that if an half-crown be placed in contact with the under part of the tongue, and a plate of zinc be applied to the upper part, on bringing the two metals into contact with each other, a pungent diſagreeable feel, which it is difficult to deſcribe, is produced at the point of the tongue.

And if a plate of zinc be placed between the gums and the upper lip, and a plate of gold be placed in the upper part

part of the tongue, when the gold is brought into contact with the zinc, the perſon ſees immediately a flaſh of lightning.

After performing this experiment repeatedly, I conſtantly felt, ſays Dr. Monro, the Profeſſor of Medicine at Edinburgh, a pain in my upper jaw, which continued for more than an hour. And in one experiment, after I had applied a blunt probe of zinc to the partition which divides the noſe into two noſtrils, and repeatedly touched it with a crown piece of ſilver applied to the tongue, I thereby produced the appearance of a flaſh of lightning, and ſeveral drops of blood fell from that noſtril. Dr. Fowler, after making a ſimilar experiment on his ears, obſerved a ſimilar effect.

The experiment of producing ſparks by ſtroking the back of a cat in froſty weather, readily ſhews that the electric fluid naturally exiſts in a very active ſtate in the bodies of ſome animals. Poſſibly, ſays the celebrated Dr. Priestley, the *light* which is ſaid to proceed from animals, as from wild beaſts, when they are in purſuit of their prey in the night, may not only ariſe, as it has hitherto been ſuppoſed to do, from the mere friction of their hairs or briſtles, but violent *muſ-*

cular exertion may alſo contribute to it. *This light* may, with the electric flaſhes from their eyes, aſſiſt them occaſionally to catch their prey; as glow-worms and other inſects are provided with a conſtant electric light for that purpoſe.

Mr. HARTMAN having neglected to ſupply his paroquet with water to waſh himſelf, he obſerved that its feathers, in a ſtate of dryneſs, were endued with a proper electrical virtue, repelling one another, and retaining their electricity even a long time after they were plucked from the body of the bird, juſt as they would have done if they had received electricity from an excited glaſs tube.

The following is a very remarkable inſtance of the exiſtence of this fluid in the human frame, and of the eaſe with which it is put into action. BRIDONE, in his travels, mentions the ſtory of a lady, who, on combing her hair in froſty weather in the dark, had ſometimes obſerved ſparks of fire to iſſue from it; this made him think of attempting to collect the electrical fire from the hair, without the aſſiſtance of any other electrical apparatus. To this end he deſired a young lady to ſtand on wax, and comb her ſiſter's hair, who was ſitting in a chair a chair before her; ſoon after ſhe had begun to comb, the young lady on the wax darted out ſparks of fire againſt every object that approached her. Her hair was ſtrongly electrical, and affected an electrometer at a conſiderable diſtance. He charged a metallic conductor from it, and in the ſpace of a few minutes collected a ſufficient quantity of electric fire ſo as to kindle common ſpirits, and, by means of a ſmall jar, gave many ſmart ſhocks to all the company preſent.

Monſ. CAVALLO alſo mentions, that he obtained, by means of a ſmall condenſing plate, very ſenſible ſigns of electricity from various parts of his own body, and from the head of almoſt every other perſon on whom he made the experiment.

The celebrated JOHN WESLEY relates, that Mrs. Suſanna Sewall, wife to Major Sewall, in New England, at a certain time of the year, never changed her apparel without obſerving a ſtrange flaſhing of ſparks. In the company of ſeveral perſons, having taken off ſome of her wearing apparel, and ſhaking it, ſparks flew forth, making a noiſe much like bay leaves thrown into the fire. They deſired Mrs. Sewall one day to put on her ſiſter's garment; and when ſhe put it off, in the evening, it ſparkled as her own uſed to do.

It has often been obſerved, that when we wear worſted under-ſtockings, and ſilk over them, if we chance to draw off the ſilk ſtocking in the dark, the bright electric fluid is ſeen flaſhing from every part of the worſted under-ſtocking.

A variety of other curious facts clearly evince, that the electric fire is eſſentially connected with the animal body, and is continually exerting its influence in it.

The electric fluid, however, is far more conſpicuous in the body of the GYMNOTUS, which has the remarkable property of generating and throwing out its electricity much beyond the limits of its own ſyſtem. I have often, ſays Dr. GARDEN, when I have taken hold of the *gymnotus* with one hand, and put the other into the water over its body, without touching it, received a *ſmart ſhock*; and I have obſerved the ſame effect to follow, when a number of perſons joined hands, the perſon at one extremity of the circle taking hold of, or touching the electric fiſh, and the perſon at the other extremity putting his hand into the water over the body of the fiſh. The ſhock was communicated through the whole circle as ſmartly as if both the extreme perſons had touched the fiſh. I am told, continues Dr. GARDEN, that ſome of theſe fiſh, in Surinam river, are upward of 12 feet long, whoſe ſtroke or ſhock proved *inſtant death* to any perſon who had the misfortune to touch it.

Monſ. FERMINS, in his Natural Hiſtory of *Surinam*, publiſhed in 1765, alſo tells us, that making 14 perſons graſp each other by the hands, while he graſped the hand of the laſt with one of his, and with the other touched the GYMNOTUS with a ſtick, the whole number felt the ſhock, and he could not prevail on any of them to repeat the experiment*.

Dr. PRIESTLEY relates, that the ſenſation is ſtrongeſt when the fiſh is in motion, and is tranſmitted to a great diſtance, ſo that if perſons in a ſhip happen to dip their fingers or feet in the ſea, when the fiſh is ſwimming at the diſtance of 15 feet from them, they are affected by the ſhock.

Mr. WALSE gives us the following beautiful experiment, to prove that the *gymnotus* is very ſenſible whether the ſubſtances brought near him are proper or not for receiving the electric ſhock.

The ends of two wires were put into the water of the veſſel, which contained the animal; theſe wires were of ſome length, ſtretched to their extent, and terminated in two glaſſes of water placed at a conſiderable diſtance from each other. Whilſt the apparatus remained in this ſtate, and the circulation was of courſe *interrupted*, the animal did not prepare to exerciſe his power, but the inſtant a ſpectator, or any conducting ſubſtance, filled the interval, and rendered the circle complete, it inſtantly approached the wires, arranged itſelf, and gave the ſhock.

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* VANDELOTT makes two ſpecies of the *electric eel*, the black and reddiſh; though he acknowledges that, excepting the difference of colour and degree of ſtrength, they are not materially different.

The ſurpriſing property of the TORPEDO, in giving violent ſhocks to the perſon who takes it in his hands, or who treads upon it, was long an object of wonder. For ſome time it was generally reckoned to be a fabulous hiſtory; but at laſt the matter of fact being aſcertained beyond a doubt, *philoſophers* have endeavoured to find out the cauſe.

As an inſulated perſon cannot receive a ſhock from either of theſe extraordinary fiſhes, the identity of this fluid, and the electric fluid, is clearly aſcertained.

Mr. HUNTER has well obſerved, ſays Sir JOHN PRINGLE, that the magnitude and number of the nerves beſtowed on the electric organs of the *torpedo* and *gymnotus*, muſt appear as extraordinary as their effects; for if we except the important organs of our ſenſes, there is no part, even of the moſt perfect animal, which, for its ſize, is more liberally ſupplied with nerves than the *torpedo:* nor yet do theſe nerves of the electric organs ſeem neceſſary for any *ſenſation* that can belong to them· and with reſpect to *actions*, there is no part of any animal, however ſtrong and conſtant its actions may be, which enjoys ſo large a portion of them. If then it be probable, that *theſe nerves* are *unneceſſary* for the purpoſe either of *ſenſation* or *action*, may we not conclude, that they are ſubſervient to the management of the *electric fluid?*

Monſ. REAUMUR has alſo reſolved it into the action of a vaſt number of *minute nerves*, ſituated in a line under the ſkin, which by their accumulated force gives a ſudden and violent ſhock. He obſerves, alſo, that when theſe animals have exhauſted their electric powers, they ſubmit quietly to every inſult; but having by a little reſt and time recovered their former force, they then haſtily repay the offence.

May not animals have a power, is the conjecture of the celebrated Dr. PRIESTLEY, of extracting from the blood the *electrical fluid*; the BRAIN then would be the great laboratory for that purpoſe; and by means of the NERVES, that great principle, thus exalted, would be directed into the *muſcles*, and contract them as *ab extra*.

The ingenious Monſ. VALLI obſerves, alſo, that the ſize and number of the *nerves*, which are beſtowed upon the *electrical organs* of the TORPEDO and GYMNOTUS are truly extraordinary and aſtoniſhing.

The nerves of the *muſcles* in animals are likewiſe very large, and their minute ramifications ſo great, that ſeveral phyſiologiſts have been led to believe that muſcular contractile fibres are the ſame thing as nervous fibrils.

The blood-veſſels of the *electrical organs* are very numerous, follow the courſe of the nerves, and diſtribute the ſmaller branches along with them.

The quantity of veſſels expended upon the *muſcles* is alſo prodigious, and they likewiſe are found to accompany the courſe and diſtribution of the nerves.

There exiſts in *muſcles* as well as in the *electrical organs* of the torpedo and gymnotus, cylinders, partitions, and a great ſubdiviſion of parts.

Have we not therefore every reaſon to believe that our *muſcles* are ſo many *electrical organs*, each muſcle being as it were a battery, and muſcular intumeſcence and contraction, in conſequence of a ſort of exploſion produced by the animal or nervous electricity *? According to this hypotheſis our nervous and muſcular ſyſtems may be conſidered, ſays Dr. **BEDDOES**, as a beautiful machinery, and muſcular motion, at leaſt that of animals analogous to man, would be a chemical operation combining *hydrogen* and *azot* with OXYGEN. This hypotheſis, though not perhaps capable at preſent of the ſtricteſt proof, appears highly probable. It accounts for the perpetual neceſſity of imbibing OXYGEN AIR, and enables us to trace the changes undergone by this ſubſtance, from the moment it is received, till the moment it is expelled. During the contraction of the muſcles, OXYGEN combines with the elements above mentioned into *water*, and *various ſalts*, among which the *marine* and *phoſphoric acids* deſerve particular notice. *In this ſtate* it is taken up by the *abſorbents*, and afterwards *exhaled* or *excreted*. Hence the neceſſity for OXYGEN AIR in the blood for *muſcular action*, and hence the reaſon why *motion languiſhes*, whenever *this principle is ſcantily ſupplied by the lungs*.

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* I once happened, ſays Dr. PRIESTLEY, to lay a chain near my electric batteries, ſo as to make it return at a ſharp angle, in order to impreſs the form of the letter *b* upon the table; and obſerved, that on the diſcharge, the part of the chain that had been *doubled* was diſplaced, *and pulled about two inches towards the reſt of the chain.* At this I was ſurpriſed, as I thought it lay ſo that it could not ſlide by its own weight. Upon this I repeated the experiment with more accuracy. I ſtretched the whole chain along the table, laying it double all the way, and making it return by a very ſharp angle. The conſequence always was, that the chain was SHORTENED about *two inches*, and ſometimes more, *as if a ſudden pull had been given it.*

The contraction of a muſcular fibre may be *compared*, ſays the illuſtrious Dr. DARWIN, to the following electric experiment. Let twenty very ſmall Leyden phials, properly coated, be hung in a row by fine ſilk threads at a ſmall diſtance from each other; let the internal charge of one phial be poſitive, and of the other negative, alternately; if a communication be made from the internal ſurface of the firſt to the external ſurface of the laſt in the row, they will all of them inſtantly *approach* each other, and thus SHORTEN a line that *might connect them together like a muſcular fibre.* Vide ZOONOMIA, p. 61.

A very delicate experiment was made by Dr. MAYOW, in the laſt century. A dog that was *panting* and *breathing* deeply, on receiving *arterial*, that is, *oxygenated* blood into one of his veins, inſtantly began to breathe ſo *calmly* that his reſpiration was ſcarce *ſenſible*. The animal here receiving from an *unuſual ſource* the ſuſtenance which is probably expended by violent muſcular action; it became *therefore* no longer neceſſary to inhale it *rapidly*.

SECT. XIII.

ON TONE.

After breathing a ſuperoxygenated air "I felt myſelf," ſays the ingenious Dr. **Beddoes**, "much more diſpoſed for, and capable of, *muſcular exertion**."

It is not from the ſleek countenance, not from the plump habit, as indicating *diſtended veſſels*, that we are to form our judgment of ſtrength, for **Hippocrates** has well obſerved, "otium humectat et corpus reddit debile; labor ſiccat et corpus robuſtum efficit." To ſee, therefore, vigour in perfection, we muſt look at the hardy and laborious ruſtic, whoſe turgid muſcles, as in the ſtatue of the Farneſian **Hercules**, can be readily diſtinguiſhed through the ſkin.

In fatting poultry we feed them to the full, but we endeavour to keep them perfectly at reſt. In conſequence of this treatment the veſſels are *diſtended*, but the fibres are relaxed, tender, and weak, in their coheſion. To fatten our ducks, we not only confine them in a place of ſmall dimenſions, but keep them from the water, becauſe we obſerve that their cold bath and exerciſe render the ſkin and all their fibres tough.

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* Vide Dr. Beddoes's Letter to Dr. Darwin, p. 51.

It may be received as an axiom, ſays the learned author of the Guide to Health, "*that the living power or* "*energy of an organ is in proportion to the quantity of oxy*"*genated blood that circulates through it.*" For it is not *merely* the *quantity* of fluids feebly creeping through the veſſels, nor *fat* ſtagnant in every part of the ſyſtem, but the *quick ſucceſſion* and *ſtrong impulſe* of *well oxygenated blood* that produces TONE and VIGOUR.

This may be more clearly comprehended, if we attend to the manner in which horſes are fed and worked upon the road. When firſt taken up from graſs they abound in fat, but are not fit for labour, becauſe, on moderate exertion, they are bathed in ſweat, and are ſoon exhauſted with fatigue. If, when taken into work, with ſixteen buſhels of oats, beſides beans, per month, and a ſmall quantity of hay, they are employed in proportion to their food, they know not what it is to feel fatigue. Their veſſels, filled with *well oxygenated blood*, contract with vital energy, the action and reaction are great, all is activity, all is vigour.

END OF THE FIRST VOLUME.